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TREASURY DEPARTMENT
UNITED STATES PUBLIC HEALTH SERVICE

PUBLIC HEALTH BULLETIN No. 109
NOVEMBER, 1920

STUDIES ON THE TREATMENT AND DISPOSAL OF INDUSTRIAL WASTES

Made under the Supervision of
EARLE B. PHELPS

(Nos. 1 and 2 published as Public Health Bulletin 97, October, 1918
No. 3 published as Public Health Bulletin 100, November, 1919)

4. THE PURIFICATION OF CREAMERY WASTES

BY
HARRY B. HOMMON

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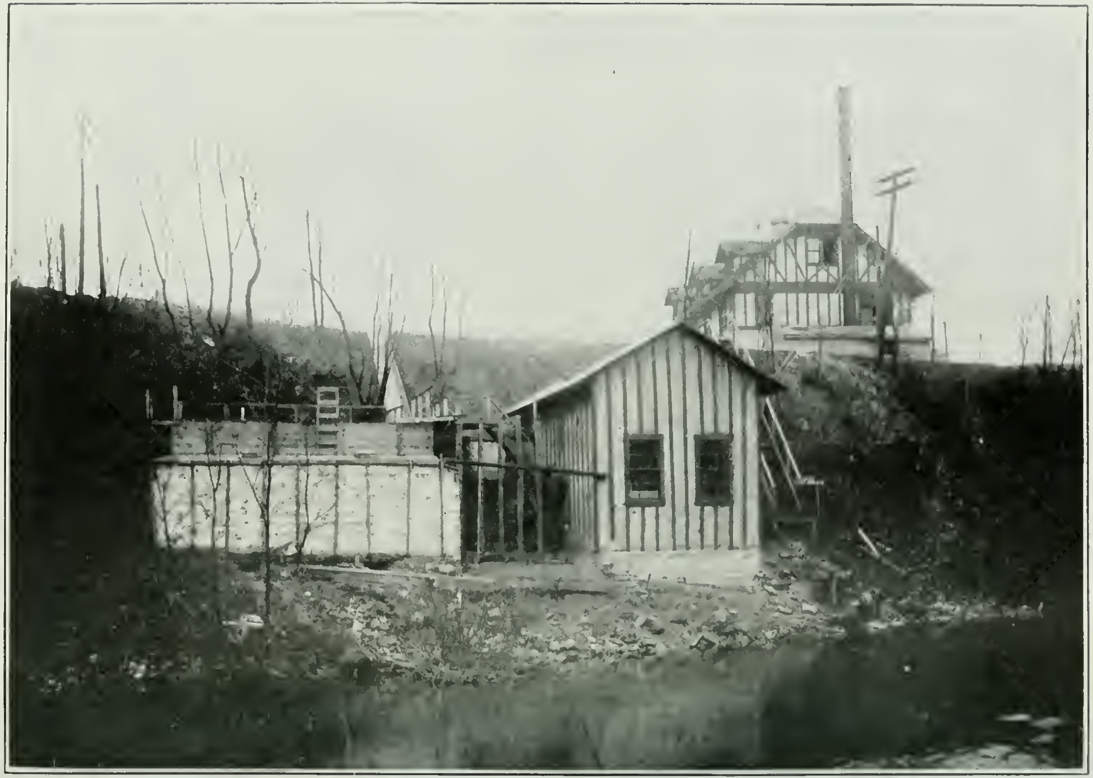

FIG. 1.—THE TESTING STATION AND CREAMERY.

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INTRODUCTION.

There is probably no industry so widely distributed as that engaged in the production, manufacture, and distribution of milk products. Because the nature of the raw materials limits the distance to which it can be transported, the dairy industry, unlike most industries which seek locations convenient to labor, fuel, etc., has developed in the territory immediate to the source of raw material. There is, therefore, to be found in every section of the country some branch of the industry, its nature depending upon the distance from the large centers of population. In the large cities or within a radius of a few hundred miles will be found the creamery, the cheese factory, skimming stations, the condensery, the milk sugar factory, the renovated or process butter factory, the milk depot, and the casein manufacturers. In the rural districts, located remote from the large centers of population, the creamery, the cheese factory, and condenseries predominate, either separately or in combination. Any or all of the divisions listed above may be found in any community, regardless of the location, but in general the creamery and cheese factories are more widely distributed and are to be found wherever farm land is suitable for dairying.

Where plants are located in cities or towns with sanitary sewers, or where large water courses are available, no difficulty has arisen in disposing of their wastes, but, in the largest number of cases, where only a ditch or small stream of water must receive the waste, nuisances have resulted that have often threatened the existence of the plants. Numerous investigations have been made in this country and abroad to learn what is the most satisfactory and economical method of purifying the wastes from the various branches of the dairy industry. Some of the methods have been successful, and a few treatment plants have been constructed that give satisfactory results, but the far greater number of purification plants that have been constructed have not operated successfully, and there is a general impression among the owners of the dairy products plants that there is no satisfactory method of treating their wastes.

The Dairy Division of the United States Department of Agriculture has received each year many requests from firms handling milk or milk products for information relating to the treatment of their wastes, and the division has been unable to supply the data necessary for properly designing treatment plants. To meet this growing demand for assistance in the dairy waste disposal problem, the Dairy Division requested the Division of Streams Pollution Investigations of the Bureau of Public Health Service to design and operate a testing station for treating wastes from the experimental creamery the Dairy Division was operating at Grove City, Pa. As the Public Health Service, under authority of an act passed by Congress in 1912,[1] was equipped to make an investigation, an arrangement was made with the Dairy Division whereby the Public Health Service would design the testing station and operate it, the Dairy Division to pay for the cost of construction and to permit the use of their laboratory for analyzing samples of the raw waste and effluents from the purification devices.

The original sketches for the design of the testing station were prepared by the writer, and the Dairy Division of the Department of Agriculture prepared the detailed plans and specifications and superintended the construction of the plant.

Sanitary Chemist H. P. Corson was in immediate charge of the operation of the testing station from the inception of the tests until July, 1917, when he was relieved to take up work in connection with the examination of water supplies used in interstate traffic.

Sanitary Bacteriologist J. W. McBurney had charge of the operation of the testing station from July, 1917, to the close of the tests.

Associate Sanitary Engineer Harry R. Crohurst assisted in the installation of the sand filters and the operation of the testing station at the start of the tests, and Associate Sanitary Engineer H. H. Wagenhals assisted in the preparation of the data for the report.

Mr. L. A. Rogers, in charge of dairy research laboratories of the Dairy Division of the United States Department of Agriculture, was instrumental in establishing the cooperation of the Public Health Service and Department of Agriculture for carrying out the tests, and throughout the time the station was operated his advice and judgment were invaluable in matters pertaining to the creamery and wastes produced.

Mr. K. E. Parks, dairy engineer, had charge of the preparation of the detailed plans for the testing station and superintended the construction.

Mr. J. C. Joslin, in charge of the creamery, and Mr. A. O. Dahlberg, of the research laboratories of the Dairy Division of the Department of Agriculture, located at the creamery, rendered valuable assistance through their active interest and cooperation in the operation of the testing station.

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[1] A law requiring the United States Public Health Service to study the pollution, "direct or indirect, of the navigable streams and lakes of the United States."

PREVIOUS INVESTIGATIONS.

The first attempt to purify wastes arising from the dairy-products industry was made in Germany about 1887. Mueller (1)[1] recommended treatment of the wastes by chemicals, but not to such an extent as to hinder the normal bacterial action that goes on in milk when stored in septic tanks. Boemer (2)[1] and Koenig (4)[1] suggested broad irrigation where soil conditions were favorable. Opperman (7)[1] advised dilution in rivers where possible, and where this method could not be used broad irrigation, selecting for the purpose soil made up of sand or gravel which could be easily underdrained.

It will be observed that the practice of treating wastes from the dairy industry in Germany tended toward chemical precipitation in a manner and to a degree that would not interfere with the ordinary decomposition of the wastes when stored in tanks and to some form of broad irrigation.

French literature on the treatment of these wastes is of a later date than is the German literature reviewed above. Schoofs (56)[1] recommended treatment in a septic tank followed by percolating filters. In a special study on filtration Kattein and Schoofs (8)[1] reported that contact beds were not as efficient as percolating filters.

Hamilton (59)[1] developed a method in which the wastes, first neutralized by lime, were treated by chemical precipitation, using sodium silicate. He stated that the sludge thus produced had considerable value as a fertilizer.

Calmette (60)[1] made a series of tests on butter-factory wastes at the Pasteur Institute at Lille. Using ferric sulphate as a precipitant, he obtained, with a dosage of 134 grains per gallon, a high removal of organic nitrogen and organic matter. He also concluded that storage of the wastes in a septic tank and the application of the effluent to sprinkling filters would produce a satisfactory effluent. Caseïn manufacturing wastes, Calmette held, could be treated in a similar manner, except that it would be necessary to neutralize the mineral acids used in the manufacturing process and to reduce the rates of filtration to about one-half or one-third.

The situation in Ireland with regard to the purification of wastes from the dairy industry was investigated by the Royal Commission of Sewage Disposal (42)[1] in 1915. The data is only of a general nature, there being no reference to treatment plants in successful operation. They concluded that land treatment was successful where soil conditions were favorable, but where this method could not be used they suggested as alternatives that the waste either be mixed with domestic sewage and, if necessary, treated on biological filters of the type suitable for purifying sewage, or that the wastes be settled in tanks and the effluent treated on biological filters, but at rates of filtration much lower than for domestic sewage. The final conclusions reached by the commission are given in the following two paragraphs copied from their report:

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[1] See Bibliography.

> Where suitable land is not available, good clarification, followed by deep percolating filters, would appear to offer an alternative means of purification, but we can point to no example of this method of treatment upon a practical scale, and it is necessary, therefore, in view of the rapid development of the dairying industry, that we should draw attention to the need for systematic investigation, directed not only to biological purification but also to the utilization of what is valuable in the waste products.
>
> In the meantime we should infer from what little work we have done on the subject, conjoined with our general experience of wastes of organic character, that dairy waste could be purified practically so as to produce an effluent containing not more than 4 parts of suspended solids per 100,000, and taking up not more than 4 parts of dissolved oxygen in five days.

The first studies made in the United States for treating dairy products wastes were carried out at the Lawrence experiment station by the Massachusetts State Board of Health (5)[1] in 1898. In these tests an artificially produced waste composed of skimmed milk and water was used. It was found that this waste, in a concentration of 1 per cent of skimmed milk, could be applied without preliminary tank treatment to sand filters 4 feet deep at a net rate of 25,000 g. a. d. and a stable effluent obtained.

Following the tests made at the Lawrence experiment station, numerous investigations were conducted by various State boards of health and other State departments interested in finding a means of abating nuisances arising in streams from the discharge of raw wastes from plants handling dairy products.

Prof. Erf (17)[1] prepared a bulletin for the Kansas State Agricultural Experiment Station on the treatment of dairy and farm sewage in which he recommended that the wastes be stored in tanks for at least 48 hours and that the effluent from the tanks be disposed of by subsurface irrigation through farm tile, the capacity of which should equal the flow for one day.

Mr. James T. B. Bowles (32),[1] of the Wisconsin State Hygienic Laboratory, made a special study of the effect of different storage periods in septic tanks. His conclusions were that storing the wastes in tanks for six days was sufficient to render the effluent stable, but that if a storage period of six days can not be obtained, it will then be necessary to provide filters. There is a question whether the stability was due to the oxidation of the organic matter or to the destruction of the reducing bacteria by the long storage of the wastes in the tank.

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[1] See Bibliography.

The Minnesota Dairy and Food Department published a bulletin in 1913 by John E. Lindberg (36),[1] in which certain recommendations are made regarding the disposal of dairy products wastes: He recommended dilutions in water courses wherever possible, but where this method of disposal is not available he suggested, as alternatives, either land treatment or storage in tanks and discharge of the effluent onto a sand and gravel filter or into leaching cesspools to drain away in the subsoil.

Officials of other States have made investigations pertaining to the disposal of dairy wastes, those of Iowa, New Jersey, New York, and Ohio in particular having devoted much time to this work. The State Board of Health of Ohio (20)[1] published a bulletin on creamery waste disposal in 1909 in which the design, construction, and costs of a proposed type plant were given. The data in this bulletin were based on experiments conducted at Columbus and at a skimming station at Blanchester, Ohio. The State board of health also cooperated with the Sunbury Cooperative Creamery Co., Sunbury, Ohio, in designing a treatment plant for purifying the wastes from butter making.

Mr. A. Elliott Kimberley (49)[1] made a special study of the operation of this treatment plant at Sunbury and the data given in his report were verified to a large extent by the tests that were made at the creamery at Grove City, Pa., which are the subject of this present report.

SUMMARY OF THE RESULTS OF THE PRESENT INVESTIGATION.

The testing station operated at the creamery at Grove City, Pa., by the Public Health Service, in cooperation with the Dairy Division of the Department of Agriculture, was designed on the basis of methods that had given satisfactory results in treating domestic sewage and had proven more or less satisfactory at other creameries. Different authorities writing on the subject of treating dairy products waste had made recommendations covering the full range of all the methods used in the treatment of domestic sewage. There was no agreement as to the proper design or the storage period in tanks, and there was a considerable difference of opinion as to what material should compose the filter beds, the depth of the beds, and the rates of filtration.

It was believed that a definite procedure could be worked out whereby manufacturers engaged in making dairy products could feel reasonably safe in installing a treatment plant for purifying their wastes that would be simple in operation and at the same time produce an effluent that could be discharged into any water course, no matter how small, without producing a nuisance. It was not anticipated that the tests would settle the treatment problem entirely, but it was hoped to develop a certain definite system that could be considered standard until something more satisfactory could be developed.

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[1] See Bibliography.

The testing station was designed by the writer and constructed under the supervision of the Dairy Division of the Department of Agriculture. It consisted of a building for housing the pumping equipment and weir boxes for measuring the waste from the creamery, an Imhoff and a septic tank, two sand filters, and other miscellaneous devices necessary for the operation of the station.

The Imhoff tank.—This tank was constructed of wood and unfortunately it was impossible to make it sufficiently watertight to prevent the leakage from developing offensive odors about the plant. As a consequence, it was necessary to abandon the tank early in the tests. It was in operation about five months, but the wastes were not applied continuously owing to the tank being out of commission for repairs. The results obtained during this time indicated that the Imhoff type of tank has no particular advantage over the ordinary septic tank properly baffled.

The particular advantage claimed for the Imhoff tank is the separation of the flow section from the sludge compartment by baffles so arranged as to permit suspended matter to fall into the sludge section and to prevent sludge borne by gas from entering the flow section. For this purpose the upper section of the tank is divided into two parts, one for the waste flowing through and the other for the escape of gas and storing scum.

There is only a small amount of settleable suspended matter in fresh creamery waste, but it usually contains floating particles of fat. Immediately upon entering the tank, however, the milk or cream begins to sour, and the suspended matter formed, having a lower specific gravity, rises to the surface and forms scum in the flow section.

When the Imhoff tank at Grove City was abandoned there was a thick scum in the flow section and only a thin layer over the gas section. While this test was not conclusive, nevertheless the evidence seemed against the use of this design of tank for treating dairy products' wastes that are subject to progressive souring in the tank, with the consequent formation of light flocculent or greasy suspended matter. There was more suspended matter in the effluent from the Imhoff tank than in the septic tank operated in parallel with it. The storage of the waste in the tank was equivalent to about 24 hours; that is, an amount of waste equal to the volume of the flow section passed through the tank in the 12 working hours of the day.

The septic tank.—This tank was operated from December 1, 1915, to October 1, 1917. It, too, leaked badly at the start, and throughout the entire time the station was operated there was some leakage, but it was never serious enough to affect the results obtained or to produce offensive odors. The storage period in the septic tank was approximately the same as that in the Imhoff tank.

Theoretically, it was planned to have all the wastes entering each tank remain in the tank 12 hours. This did not work out in actual practice during the day, but there was always a 12-hour storage at night, and this was sufficient to develop the maximum acidity of the wastes and a bacterial flora strong enough to acidify the wastes receiving the shorter detention period that obtained during the day when it was entering the tank. As will be shown later, in the discussion of the results obtained from the sand filter, the tank capacity should at least equal the volume of waste per 24 hours plus 30 per cent additional for sludge and scum.

Tank treatment was not studied as a means of purification, except in connection with sand filtration, and the minimum storage period referred to above is, therefore, to be considered only in connection with sand filtration. It is not believed that longer storage of the waste in tanks would render the effluent less amenable to filtration through sand, but the tests, extending over more than a year, indicated that a minimum of 24 hours is sufficient preparation of the waste for complete oxidation in sand filters. There was, however, considerable suspended matter in the effluent of the tanks which clogged the surface of the beds. In order to reduce the labor involved in taking care of the filters it will be advisable to design the tank on the basis of 48 hours storage with an additional allowance of 30 per cent for scum and sludge accumulations.

As already indicated, there were pronounced odors about the two tanks in the spring following the first winter of operation. Both tanks leaked badly at the beginning of the tests, and the Imhoff tank had to be abandoned on account of odors arising from this leakage. Had the tanks been used for treating domestic sewage or other industrial wastes, with which we are familiar, it would not have been necessary to discontinue the use of the Imhoff tank or to employ special precautions to stop all leakage from the septic tank. In treating a dairy waste, however, it is very important to have all devices water-tight, and it is likewise necessary to provide covers for the tanks. This will be particularly true during the entire first year of operation and during the spring of subsequent years.

Since wastes from the dairy-products industry may develop very offensive odors when undergoing decomposition in tanks, disposal plants should, as a matter of precaution, be located at least 200 yards from the factory and all other buildings where people work or live.

Sludge and scum disposal.—Because both the sludge and scum give off very offensive odors they can not be exposed on drying beds. such as are used for similar by-products in the treatment of sewage and most other industrial wastes. The most practical method of disposal is scattering over the surface of ground remote from any buildings. If it is desirable or necessary to effect disposal near the creamery plant or in the vicinity of any other buildings, burial is the only method available. Shallow trenches should be used for this purpose to receive the sludge or scum which must then be immediately covered with a few inches of earth. By this means the fertilizing ingredients of the waste will be utilized and no nuisance will result. The grease in the solids removed from the tanks has no commercial value, and it is not believed that it will have any deleterious effects on the soil when applied as described above.

Sufficient openings should be left in the cover on the tank to permit the removal of the scum by shovels. Sludge pipes, extending from the bottom of the tank to about 2 feet below the surface of the liquid in the tank, should be used to drain off the sludge accumulating over the bottom of the tank. Where the tanks are so located that the sludge can not be removed by gravity flow or hydrostatic pressure it will be necessary to provide pumps. It will probably be found more satisfactory to remove only the dry scum from the surface and the concentrated sludge from the bottom of the tank rather than to attempt to remove all the scum and sludge at one time. The dry scum and the concentrated sludge will represent more than 50 per cent of the entire accumulation but, being compacted, will not be large in volume. If, however, it is attempted to remove the thin watery scum and sludge, it will be necessary to remove with them a large amount of liquid waste, which will not only increase the cost but intensify the odors.

Sand filters.—Throughout the Grove City tests the effluent from the septic tank was treated on sand filters, made of 4 feet of sand and 1 foot of coarse stone underdrainage. The sand, obtained locally, was of medium size and clean.

The settled waste was applied to the filters at rates varying from 25,000 g. a. d. at the beginning of the tests up to 75,000 g. a. d. during the last few months of operation. The results obtained with the higher rates were entirely satisfactory and justify the conclusion that, where careful attention is given in the creamery to prevent skimmed milk, buttermilk, or whey from getting into the sewer, filters can be designed to treat the wastes at a rate of 75,000 g. a. d.; but, if there is doubt as to the amount of such products being emptied into the creamery sewer, it will be advisable to provide filter areas for rates not higher than 50,000 gallons.

The effluent from the septic tank was applied to the filters continuously during the time wastes were being discharged from the creamery. The filter effluent was clear, well nitrified, stable, and supported fish life for more than a month without any apparent discomfort. The quantity of waste treated on the filters was too small to permit intermittent dosing through siphons. In large plants the siphon method of application should be used, but the siphons should be so arranged as to apply a large number of small doses per day rather than a small number of large doses.

Analytical methods used.—The analytical methods used for the chemical and bacteriological work were, with the exception of the oxygen demand determination, those recommended by the Standard Methods of the American Public Health Association. The following determinations were made according to the procedure outlined:

The total solids or residue on evaporation were determined by evaporating a definite volume of the waste in a platinum dish, drying the residue in a steam-drying oven, and weighing. The suspended matter was determined by passing a measured volume of the waste through a Gooch crucible and weighing the crucible and residue after drying in a steam oven.

The turbidity of the raw waste and effluents was obtained by comparing samples in half-gallon bottles with standards made up of a suspension of Pear's precipitated fuller's earth. This method is explained in the Standard Methods of the American Public Health Association for 1917.

The organic nitrogen and free ammonia were determined by the direct process. A sample of the waste or effluent was digested with sulphuric acid until the organic matter was reduced. It was then diluted, neutralized, and a portion of the digestate nesslerized and read without distillation. The free ammonia or ammoniacal nitrogen was found by adding a small amount of sodium hydrate and copper sulphate to the sample, allowing the precipitate to settle, and then pipetting off an amount of the supernatant that gave a proper reading when nesslerized.

The nitrates were determined by the reduction process and the nitrites by the method outlined in Standard Methods.

The alkalinity was obtained by using methyl orange as an indicator, and the acidity by phenolphthalein in a boiling solution, titrating with potassium hydrate.

The oxygen consumed of the raw waste and effluents was determined by immersing samples containing sulphuric acid and an excess of potassium permanganate in boiling water for 30 minutes. The permanganate remaining in the sample at the end of 30 minutes was titrated according to Standard Methods to find the amount used by the sample.

The oxygen demand was obtained by the excess oxygen method. Samples were diluted with water of known dissolved oxygen content and incubated at 20° C. for 24 hours, 5 and 10 days, and the loss of oxygen was determined. This method [1] was developed at the Public Health Service laboratory at Cincinnati from the technique used by other laboratories.

Putrescibility results were reported as the number of hours required to reduce methylene blue in samples stored at room temperature. On the average this was about 65° F., except during the warm months, when the average was approximately 75° F.

The dissolved oxygen was determined by the method given in Standard Methods of the American Public Health Association for 1917.

The fats in the raw waste and sludge were reported as ether soluble matter and were determined by treating the dried residue of the raw waste or dried sludge with ether and weighing the dried fat.

The bacteriological results were reported as the total count in nutrient agar at 30° C. after 48 hours' incubation, and the total number of red colonies on Endo plates at 30° C. The temperature of 30° C. was used for the reason that 37° C. standard incubators were not available and space in the 30° C. incubators used by the creamery could be utilized.

DESCRIPTION OF TESTING STATION.

The testing station was located on the bank of Wolf Creek about 100 feet from the rear of the creamery. It consisted of a frame building 20 by 20 feet in plan and 30 feet high, in which were located the scum tank and weir box, the pumping equipment, and the storage tanks for collecting the waste after passing through the tanks and the filters. Outside the buildings were the Imhoff and septic tanks and two sand filters. (See fig. 1.)

SCUM TANK AND WEIR BOX.

All the wastes from the creamery were discharged into the weir box at the testing station, except for a short time previous to the close of the tests, when the volume of waste became so great that it was necessary to divide the flow at the outlet from the creamery and permit about half to go direct to the sewer. At the beginning of the tests a scum tank preceded the weir.

Scum tank.—This was a wooden tank 4 by 5, by 3 feet 2 inches effective depth, installed to receive the waste as discharged from the sewer from the creamery. It was intended to remove the froth

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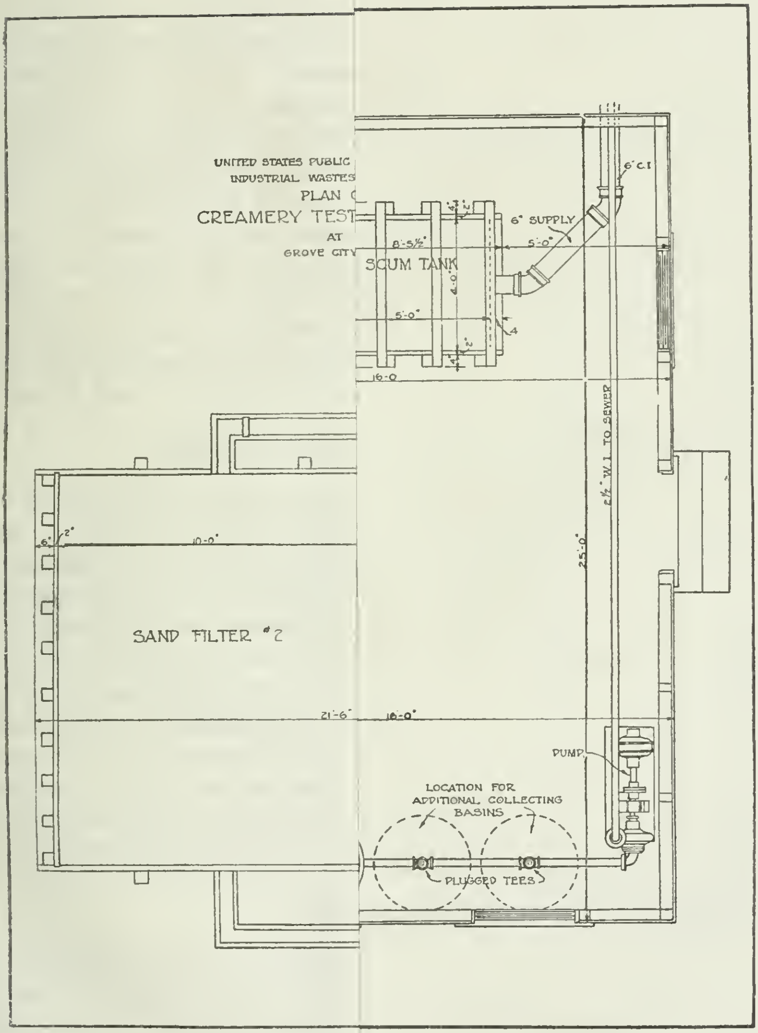
[1] Thierault and Hommon. The Determination of Biochemical Oxygen Demand of Industrial Wastes and Sewage. Public Health Bulletin No. 97.



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and scum that might form on the waste if discharged from the sewer directly into the first treatment devices of the testing station. There was, however, no foaming of the waste and, because this tank acted as a settling tank, it was abandoned early in the tests and the waste discharged directly into the weir box.

Weir box.—This tank, which was 3 by 2 feet, by 7½ inches deep, received the waste from the scum tank, or, after this tank was abandoned, direct from the creamery sewer. The inlet pipe was turned down and submerged near one side. Three outlet weirs were set in the centers of the three other sides. A stilling baffle was placed across the tank between the sewer outlet and the two weirs set in the sides at right angles to the sewer outlet. Two of the weirs were used for measuring the wastes treated in the tanks, a weir for each tank, and a third for measuring the excess that did not pass through any of the devices of the testing station.

Weir readings were taken every 30 minutes as a daily routine, and frequently 15-minute readings were taken to determine the fluctuations of flow for shorter intervals.

STORAGE TANKS AND PUMPING EQUIPMENT.

When the two tanks were in operation the total flow of waste from the creamery was divided between them, and the excess of the effluent from the tanks over that required for the filters was discharged into storage tanks and pumped back to the city sewers. The effluent from the filters was also collected in a pipe and discharged into the storage tanks. These consisted of two connected 50-gallon barrels. A 1½-inch centrifugal pump, direct connected to a 5-horsepower motor, was used for pumping the wastes from the storage tanks to the city sewer. It was automatically controlled by a float which operated whenever the waste reached a certain height in the storage tanks. This apparatus was entirely satisfactory and required but little attention throughout the entire period of the tests.

SETTLING TANKS.

Imhoff tank.—The dimensions of this tank were 8 by 6, by 12 feet deep. It was designed on the horizontal-flow plan, with one gas vent to the side. The flow chamber had a capacity of about 1,150 gallons, and the volume of the tank outside of the flow section was 371 cubic feet, or 2,780 gallons.

This tank was started in operation December 1, 1915, but was abandoned early in the tests owing to the difficulties encountered in making it water-tight. The leakage came from the sludge section, and it had such a strong odor that the residents living near, about 100 yards away, complained, and it became necessary to close the tank down on June 1, 1916. During the time the tank was in service only a few samples were taken for analysis, as it was out of operation frequently while attempt was made to make it watertight.

Septic tank.—This was a wooden tank 10 by 6, by 8 feet deep. There was one hopper 2 feet deep, 6 by 10 feet at the top, and 8 by 12 inches at the bottom. The sludge outlet pipe was located just above the center of the hopper and extended up and through the side of the tank at a point 2 feet below the surface of the water. The outlet of the tank was a 4-inch iron pipe set 9 inches below the top, thus giving an effective working depth of 7 feet 3 inches. There were three baffles placed in the tank: One 2 feet from the inlet, extending from the top of the tank down to a depth of 4 feet; one at the center, starting at the top of the hopper bottom and extending up 3 feet; and the third, 1 foot from the outlet, extended down 4 feet from the top of the tank. The first two baffles were intended to cause a thorough mixing of the waste passing through the tank and the third to prevent scum from escaping with the effluent.

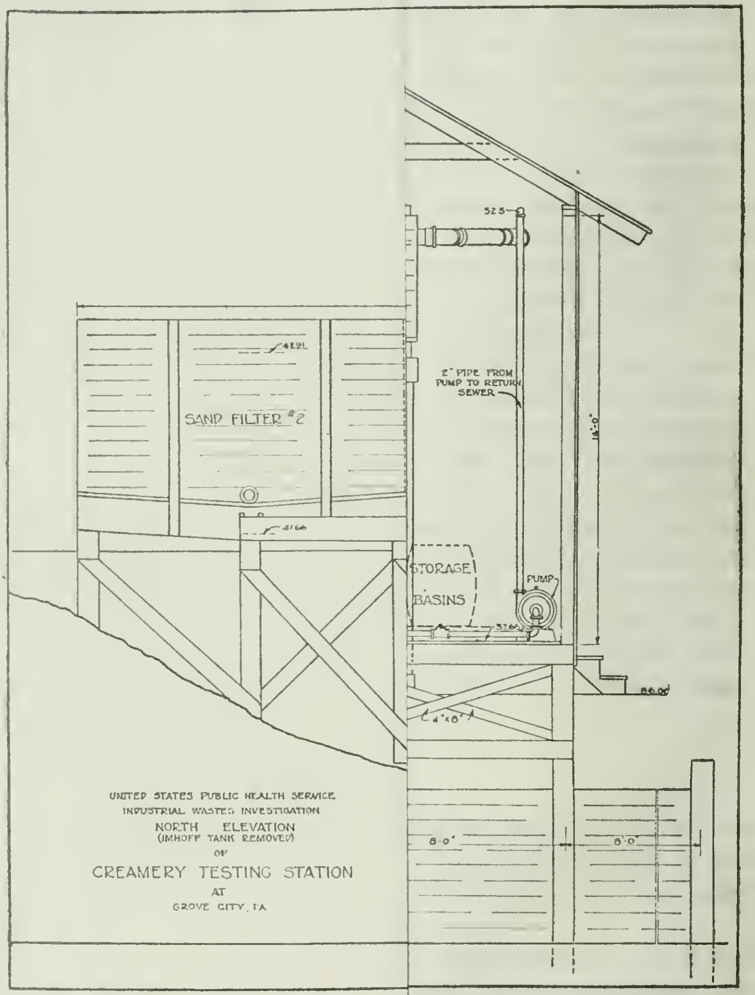
When originally constructed a loose wooden cover was placed over this tank, but when active decomposition started in the spring, following the first winter of operation, such strong odors developed that it was necessary, in order to prevent these odors from escaping, to cover the tank with 2-inch plank and to cover these with a 1-foot layer of puddled clay. It was also necessary to submerge the inlet and outlet pipes. This latter precaution was necessary to prevent the large "green bottle fly" from entering the tank and depositing eggs in the scum. Before these steps were taken the scum was a seething mass of maggots, and the intensity of the odors was no doubt influenced by the constant agitation due to their movement, which tended to release entrained gases.

SAND FILTERS.

The two sand filters were located outside the building just beyond the two tanks. Each was contained in a wooden box 10 by 12 feet in plan and 6 feet deep. The bottoms were sloped toward the center for drainage.

The filtering media consisted of 1 foot of coarse stone and 4 feet of sand. The coarse stone, averaging 4 to 6 inches in diameter, was placed on the bottom and the smaller sizes used to fill in the voids and prevent sand from working through to the bottom of the beds. The sand, obtained from a local dealer, was classed as washed river sand. It had an effective size of 0.23 mm. and a uniformity coefficient of 2.17.

Originally 4 feet of sand was placed over the broken stone. As it was occasionally necessary, however, to remove some grease-clogged



UNITED STATES PUBLIC HEALTH SERVICE
INDUSTRIAL WASTES INVESTIGATION
NORTH ELEVATION
(IMHOFF TANK REMOVED)
OF
CREAMERY TESTING STATION
AT
GROVE CITY, PA

12526°—21. (To face page 17.)

sand from the surface, the depth was reduced to 3½ feet before the tests were concluded. While this latter depth apparently gave as satisfactory results as the original 4 feet, it would not seem advisable to plan for an initial depth of less than 4 feet, thus making allowances for necessary operating losses.

OPERATION OF TESTING STATION.

The testing station was constructed in the fall of 1915 and started in operation December 1. As already mentioned in the discussion of the design of the Imhoff and septic tanks some trouble was experienced in making the tanks water-tight, so that regular routine operation did not begin till January 1, and at this time only the septic tank could be considered as being normal. The Imhoff tank was operated irregularly up to June 1, when it was abandoned.

VOLUME OF WASTE DISCHARGED FROM CREAMERY.

From May 16, 1916, to July 9, 1917, all the waste from the creamery was diverted to the testing station and weir measurements taken on 137 days. Ordinarily weir readings were taken every 30 minutes but frequently 15-minute readings were recorded for the purpose of obtaining more accurate data on the flow. There were approximately 4,800 weir measurements taken in the tests.

In previous reports, prepared by various authorities, relating to the volume of wastes of creameries, the wastes are reported as the number of gallons per pound of butter made and the figures vary from 1 to 2 gallons. At the creamery at Grove City, however, similar data could not be obtained for the reason that a part of the cream received was sold as such and other products were made from which wastes were produced. Although all the cream received was not made into butter and all the wastes produced did not come from butter making, it has seemed advisable to apportion the wastes according to some one product in order that the data can be compared with that from other creameries. The cream received was the only product to which the wastes could be referred, and the butter fat in it was used as the unit since it was a factor accurately determined for all raw material received. There is justification for using the amount of butter fat received as the unit for apportioning the wastes since all products delivered to a creamery are convertible to a butter-fat basis.

On the days that measurements of the flow from the creamery were made, data relating to products received and made in the creamery were obtained. This data together with the flow records are given in Table 1:

TABLE 1.—*Average daily amounts of milk and cream received, products made, and wastes produced.*

Month.	Pounds received.				Fat sold as cream.		Butter.			
							Tubs.		Prints.	
	Days recorded.[1]	Milk.	Cream.	Equivalent in butter fat.	Days recorded.[1]	Pounds.	Days recorded.[1]	Pounds made.	Days recorded.[1]	Pounds made.
1916.										
May	12	5,229	3,769	1,229	11	58.4	9	1,461	5	768
October	3	3,614	2,920	943	3	92.8	1	130	4	1,292
November	8	4,596	3,673	1,232	8	110.2	1	64	10	1,481
December	17	5,903	3,657	1,309	17	365.2	....	....	13	1,509
1917.										
January	16	7,353	4,222	1,527	14	293.1	6	1,144	12	1,423
February	15	8,542	4,421	1,621	12	50.2	4	1.604	10	1,978
March	18	12,193	4,726	1,866	17	56.6	11	1,848	13	1,685
April	10	13,582	5,857	2,201	10	64.9	6	1,651	7	1,328
May	22	12,574	5,103	1,911	22	65.9	22	1,877	10	789
June	13	15,381	6,172	2,297	13	83.2	13	1,857	11	917
July	3	14,204	6,144	2,219	3	102.5	3	1,862	2	1,068

Month.	Cottage cheese.		Casein.		Condensed milk.		Wastes produced.			
	Days recorded.[1]	Pounds made.	Days recorded.[1]	Pounds made.	Days recorded.[1]	Pounds made.	Days recorded.[1]	Total gallons.	Days recorded.[1]	Per pound butter fat received, gallons.
1916.										
May	12	632	3	27	....	....	12	3,598	12	3.0
October	1	534	2	48	2	1,169	5	2,540	3	2.8
November	5	475	3	64	5	963	15	2,193	8	2.2
December	16	438	....	....	19	956	24	2,549	17	2.4
1917.										
January	19	467	....	....	21	907	25	3,178	16	2.4
February	20	433	....	....	19	1,255	21	4,985	15	3.3
March	27	898	1	24	20	1,420	27	4,675	18	2.8
April	13	1,197	....	....	10	1,134	14	3,989	10	2.3
May	19	661	10	62	20	2,666	22	6,550	22	4 0
June	13	926	10	70	13	3,216	13	9,844	13	4.4
July	3	698	2	77	3	3,233	3	10,253	3	4.7
Weighted average	....	....	....	....	....	....	....	....	137	3.1

[1] Records given only for days wastes were measured.

The data in the preceding table show the amount of raw products received, products made, and the number of gallons of waste per pound of butter fat received. These figures are the monthly averages for the days when measurements of the wastes were made. The weighted average number of gallons of waste per pound of butter fat received is 3.1. This amount is approximately twice that given for butter factory wastes in other published reports. The United States Public Health Service has, however, recently obtained data in a survey of industries producing industrial wastes which show that butter factories often discharge waste as high as 3 gallons per pound of butter made.

CHARACTER OF WASTES PRODUCED.

The character or composition of an industrial waste is a more important factor than the volume when considered in connection with treatment processes, since the composition determines what the nature of the treatment will be and the volume only the size of the units. In comparing wastes from different creameries, therefore, the composition of the wastes is the only basis that can be used if comparison is made for the purpose of deciding on treatment processes. The source of the wastes in the creamery is important also in comparing wastes from different plants since different creameries making similar products do, most likely, produce waste of like character. The individual wastes that made up the composite for any one day at the testing station consisted of the following general classes:

(1) Waste water from washing churns, cans, and other utensils. Under this heading are included the wash water from cleaning all apparatus used in the creamery.

(2) Scrub and rinse water from the floors. This waste includes the milk, cream, buttermilk, and skimmed milk spilled on the floors and the miscellaneous dirt that collected.

(3) All acids used in testing the milk, together with the chemicals from the laboratory used in connection with the creamery and testing station.

(4) Waste from toilets and wash rooms.

For the purpose of showing the relation of the composition of the waste studied in the Grove City tests to those of various other dairy products wastes, Table 2 has been prepared.

TABLE 2.—*Table showing weighted average of raw waste at Grove City testing station, and analyses of wastes*[1] *from various branches of dairy industry.*

Source of samples.	Results in parts per million.								
	Organic nitrogen.	Nitrogen as ammoniacal.	Oxygen consumed.	Suspended matter.	Total solids.	Ether soluble matter.	Chlorine.	Acidity to phenolphthalein.	Alkalinity.
WASTES FROM MAKING BUTTER, COTTAGE CHEESE, CONDENSED MILK AND CASEIN.									
Grove City Creamery, Grove City, Pa.	84	1.65	782	517	3,238	245	415	[2] 153	[3] 152
BUTTER FACTORY WASTES.									
Sunbury Cooperative Creamery Co., Ohio State Board of Health (composite sample)	480	2.40	1,470	......	......	......	......	240	......
Butter Factory, Zanesville, Ohio State Board of Health	80	2.50	480	2,475	......	......	......	544	......
Uxbridge Creamery, Massachusetts State Board of Health	138	2.10	512	......	......	......	......	......	......

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[1] From report of A. E. Kimberly, Ohio Public Health Journal, Vol. VII, No. 7, 1916.

[2] Averages for days when waste was acid.

[3] Averages for days when waste was alkaline.

TABLE 2.—*Table showing weighted average of raw waste at Grove City testing station, and analyses of wastes from various branches of industry*—Continued.

Source of samples.	Results in parts per million.								
	Organic nitrogen.	Nitrogen as ammoniacal.	Oxygen consumed.	Suspended matter.	Total solids.	Ether soluble matter.	Chlorine.	Acidity to phenolphthalein.	Alkalinity.
BUTTER FACTORY WASTES—Continued.									
Elkhorn Creamery, Elkhorn, Wis., Bowles-Eng. Record, 1911, Vol. 64, p. 419[1]	132	26.40	312	521	......	......	......	......	......
Garnet Creamery, Wisconsin, Bowles-Eng. Record, 1911, vol. 64, p. 419[1]	317	38.50	261	668	......	......	......	......	......
Royal Commission on Sewage Disposal, Eng. Ninth Report, Dairy No. 68–a	86	52.40	994	962	......	......	......	135	......
SKIMMING STATION WASTES.									
Blanchester, Ohio, Ohio State Board of Health (composite samples)	249	4.00	966	......	......	......	......	518	......
Do	250	17.00	2,845	......	......	......	......	......	......
Do	115	14.00	751	......	......	......	......	230	......
Do	68	1.60	494	......	......	......	......	142	......
Do	52	46.00	107	......	......	......	......	303	......
Equal parts skimmed milk and water, Massachusetts State Board of Health	1,980	60.00	7,500	......	......	......	......	......	......
One part skimmed milk and 35 water, Massachusetts State Board of Health	230	16.50	425	......	......	......	......	......	......
CHEESE FACTORY WASTES.									
Royal Commission on Sewage Disposal, Eng. Ninth Report, Dairy No. 62	104	3.40	1,247	535	5,492	......	......	540	......
Royal Commission on Sewage Disposal, Eng. Ninth Report, Dairy No. 66	1,298	130.00	3,900	......	46,056	......	......	4,173	......
Ohio State Board of Health, whey included in washings	643	2.00	13,410	......	......	......	......	1,475	......
CONDENSORY WASTES.									
Royal Commission on Sewage Disposal, Eng. Ninth Report, dairy No. 67	......	0.15	78	54	......	......	......	36	......
Ohio State Board of Health, washings from aerator	329	7.00	2,028	......	......	640	......	642	......
RENOVATED BUTTER FACTORY WASTES.									
Chance sample from butter crystallizer, Ohio State Board of Health	68	1.40	720	......	......	......	330	75	340
Do	82	1.80	750	......	......	......	270	88	320
Do	61	1.80	520	......	......	......	26	100	320
Chance sample, wash water from churn, Ohio State Board of Health	1,163	2.00	9,160	......	......	......	1,225	1,163	480
Chance sample from butter fat separator, Ohio State Board of Health	45	0.80	330	......	......	......	110	75	310
WASTE FROM CONDENSING MILK FOR ICE CREAM MANUFACTURE, FROM BOTTLE WASHING, AND FROM CHEESE MAKING.									
Ohio State Board of Health, composite sample	23	0.40	12.5	......	839	25	130	12.5	300

[1] Probably composite samples, though not specifically so stated by the author.

The results given above illustrate very well the wide ranges of values within which the results of analyses of concentrated waste may lie. Variations occur not only as between different types of waste from dairy products processes, but also as between different samples of wastes produced in any one process. To generalize analyses from the wastes of the dairy industry, compositing of samples is essential, but even this in itself fails to afford any definite basis for comparison.

It is only by the consideration of a large number of composite samples covering extended periods that we can arrive at any conclusions. A rapid glance through the results obtained for individual samples at Grove City, as found in Appendix III, will show values both higher and lower than those given for comparable samples in the above table.

Several generalized statements may, however, be made from the values given in Table 2. With organic nitrogen, the result, as given for Grove City, is distinctly lower than those for 10 out of the other 23 samples recorded. Of the remaining 13 all but one fall well within values upon which treatment methods might be predicated. With the oxygen consumed the result recorded for Grove City is materially higher than 10 of the other results, lower than 8, and comparable with 5.

The above comparisons include all of the recorded analyses, regardless of the fact that many are special samples from individual processes. Restricting the comparison to the 8 samples which are considered to represent composite wastes, as does the Grove City sample, the organic nitrogen result for Grove City is considerably lower than 5, higher than 1, and approximately the same as 3. The average of the 8 is 151, as compared with 84 from Grove City. Extending this comparison to the oxygen consumed, the Grove City results are higher than 5 of the 8 other results, lower than 2, and similar to 1. The average of the 8 is 719, as compared with 782. In this average are included values ranging from 12.5 to 2,845 p. p. m.

The amount of suspended matter and the relation of the acidity and alkalinity to each other will depend in a very large measure on the time of flow from the creamery to the sampling point, and whether sterilizing agents have been added to the samples in sufficient quantity to prevent scouring of the waste during the period of collection and forwarding of samples to the laboratory. At the testing station less than 3 minutes were required for the waste to reach the sampling point, and all samples were completely sterilized with chloroform.

During the tests 99 samples of raw wastes were collected, covering 198 days and composed of 3,960 separate portions. The analyses of these individual samples may be found in Appendix III. Table 4 contains monthly averages based on these individual analyses.

It is believed that the weighted average given in Table 2 for the waste discharged from the Grove City Creamery is a fair average over a long period of time for wastes from all branches of the dairy industry, with the possible exception of cheese making. In regard to the latter, it is believed that the strength of the waste depends on the amount of whey discharged, and if the amount is reduced to the minimum the composition will not vary to any great extent from those treated in the tests.

IMHOFF AND SEPTIC TANK TREATMENT.

THE IMHOFF TANK.

This tank was started in operation on December 1, 1915, and operated irregularly until June 8, 1916, when it was discontinued for reasons already explained. The difficulties encountered in using this tank were sufficient to warrant a general recommendation against the use of wooden tanks in connection with creamery wastes disposal plants. Leakage that would have been permissible in treating other wastes caused such an odor at the testing station that the existence of the plant was threatened by the residents living near it. There was, moreover, considerable odor from the surface of the tank during the spring of 1916, due to the heavy scum that formed during the preceding winter, but this was entirely stopped by covering the tank tightly with matched lumber and placing a layer of earth over it. The cover not only stopped the escape of odors but it prevented the large "green bottle fly" from laying eggs in the scum. When the odors were strongest the scum was fairly alive with maggots, and it is believed that the action brought about by them, both mechanically and possibly chemically, had much to do with the intensity of the odors. Later on, when the covers were removed from the Imhoff and septic tanks, the larvæ were absent, and the escaping odors, while strong, were not nearly so offensive as they were in the spring before tight covers were installed.

The scum that formed in the flow section of the tank was thicker than that in the scum section proper, and it was of a more greasy nature. This was to be expected, since the sweet milk and cream entering the tank soured and the curd rose to the surface. The particles of butter in the waste naturally remained on the surface and mixed with the curd. The accumulation in the scum section of the tank contained miscellaneous suspended matter mixed with some curd and fat that settled through the slots in the flow section to the bottom of the tank, and later rose to the surface due to gas formed from the bacterial action in the sludge.

The Imhoff tank was not operated regularly for any length of time until the middle of May. Beginning on the 16th, four composite samples were taken covering eight days. The results of these analyses, together with those for the influent on the same days, are given in Table 3. While the analyses given represent only a very short period of time, it should be borne in mind that some wastes had been going through the tank since December 1, 1915, and comparison can therefore be made with the results obtained for the same period of operation of the septic tank. The difference in operation of the two tanks up to May 16 would have worked to the advantage of the Imhoff tank, as the irregular operation permitted a longer storage period in the Imhoff tank.

TABLE 3.—*Monthly averages of chemical and bacteriological analyses of influent*[1] *and effluent of Imhoff tank.*

	Temperature, ° F.			Chemical analyses (p. p. m.).									
							Nitrogen as—						
	Influent.	Effluent.	Air.	Suspended solids.	Residue on evaporation.	Turbidity.	Total organic.	Ammoniacal.	Nitrites.	Nitrates.	Acidity.	Oxygen consumed 30 minutes 96° C.	Oxygen demand 24 hours at 20° C.
1916.							Influent.						
May 16–17	74	74	56	286	....	1,750	254	2.0	....	....	64	2,550	......
May 19–20	78	72	49	200	6,834	1,700	184	0.8	....	....	144	2,220	2,200
May 22–23	73	72	57	672	....	1,400	140	1.0	....	....	124	1,810	......
May 25–26	77	80	62	1,048	5,692	2,000	152	1.5	0.016	....	150	2,200	3,300
Average	75	75	56	552	6,263	1,712	182	1.3	0.016	....	120	2,195	2,750
1916.							Effluent.						
May 16–17	......	......	......	432	....	1,300	128	12.0	....	....	148	1,760	......
May 19–20	......	......	......	232	3,200	660	84	4.0	....	0.002	324	1,410	2,400
May 22–23	......	......	......	332	....	700	88	2.4	....	0.250	316	1,260	1,960
May 25–26	......	......	......	412	2,588	780	56	4.0	0.012	0.012	208	910	1,560
Average	......	......	......	350	2,890	860	89	5.6	0.012	0.063	249	1,335	1,973

[1] Raw waste.

THE SEPTIC TANK.

This tank was operated continuously from December 1, 1915, to October 23, 1917. Up to May 16, however, no samples were taken as the officer in charge was giving all his attention to establishing a laboratory, getting the tanks water-tight and working out a standard routine of operation. From the time the first samples were taken to the close of the tests 100 composite samples were taken, each composed of half-hourly portions and covering two days. The analyses, therefore, represent the composition of 4,000 small samples collected over a period of 200 days.

The monthly average analyses of the influent and effluent of the septic tank and the weighted average analysis for the entire time the tank was in operation are given in Table 4.

TABLE 4.

Monthly averages of chemical and bacteriological analyses of influent[1] of septic tank.

	Temperature, ° F.			Chemical analyses (p. p. m.).														Bacteria (1,000 per c. c.).	
				Suspended solids.	Residue on evaporation.	Turbidity.	Nitrogen as—			Alkalinity.[2]	Acidity.[3]	Chlorine.	Ether soluble matter.	Oxygen consumed: 30 min. 96° C.	Oxygen demand at 20° C.				
	Influent.	Effluent.	Air.				Total organic.	Ammoniacal.	Nitrites.						24 hours.	5 days.	10 days.	Agar, 30° C., 48 hours.	Endo plates, red colonies.
1916.																			
May	75	74	56	552	6,263	1,712	182	1.32	0.004	....	120	....	....	2,195	2,830	....	....	....	....
June	73	72	63	333	4,044	725	132	.45	.006	....	131	....	....	1,082	880	....	....	....	....
July	76	77	71	290	2,426	522	76	.82	.005	203	....	....	....	599	910	....	....	....	....
August	78	74	64	460	3,075	939	76	1.29	.014	174	....	....	....	630	730	....	....	....	....
September	63	59	49	538	3,686	1,114	98	3.03	.007	157	....	....	....	879	580	....	....	....	....
October	72	66	40	562	2,172	900	58	1.50	.010	226	....	....	....	487	510	....	....	....	....
November	70	63	35	833	3,641	1,250	106	.88	.003	115	236	116	....	767	470	1,500	....	....	....
December	69	64	27	577	3,135	....	84	1.79	....	99	132	545	....	717	590	....	....	....	....
1917.																			
January	70	65	24	567	2,535	....	95	.83	.025	205	116	447	98	578	630	1,480	....	....	....
February	69	64	15	601	2,837	....	106	1.10	.014	70	....	....	186	802	680	....	....	....	....
March	71	67	31	1,114	4,678	....	122	1.22	.006	108	220	....	318	1,285	920	....	....	....	....
April	65	65	30	916	2,420	....	78	2.10	....	68	32	....	426	757	630	1,270	....	....	....
May	74	63	53	525	2,444	....	66	.65	.015	94	....	....	254	762	412	976	1,133	....	....
June	78	73	65	531	....	....	62	.78	.075	100	70	....	....	628	672	1,524	....	....	....
July	77	75	74	380	....	....	44	.76	....	160	153	....	....	816	570	1,103	1,566	....	....
August	76	75	69	400	....	....	34	1.72	....	300	125	....	....	468	440	1,114	1,272	2,784	446
September	74	72	56	360	....	....	67	2.82	....	223	220	....	....	716	490	1,477	1,984	2,798	708
October	73	68	45	386	....	....	72	5.17	....	....	185	....	....	715	460	1,766	2,104	3,770	1,425
Weighted average	73	69	50	517	3,238	954	84	1.65	.010	152	153	415	245	782	703	1,373	1,696	3,150	884

[1] Raw waste.

[2] Averages for the days when waste was alkaline.

[3] Averages for the days when waste was acid.

Monthly average of chemical and bacteriological analyses of effluent of septic tank.

	Chemical analyses (p. p. m.).													Bacteria (1,000 per c. c.).	
	Suspended solids.	Residue on evaporation.	Turbidity.	Nitrogen as—				Alkalinity.[1]	Acidity.[2]	Oxygen consumed: 30 min. 96° C.	Oxygen demand at 20° C.			Agar, 30° C., 48 hours.	Endo plates, red colonies.
				Total organic.	Ammoniacal.	Nitrites.	Nitrates.				24 hours.	5 days.	10 days.		
1916.															
May	237	2,636	652	106	17.7	0.055	0.005		634	1,402	2,610				
June	230	2,516	775	115	20.8	.051			466	429	1,099				
July	249	1,604	522	54	25.8	.010			191	232	951				
August	276	1,755	1,019	57	22.9				166	236	669				
September	329	2,101	1,071	44	27.3	.014			239	315	577				
October	278	1,628	800	35	27.2	.008			40	182	508				
November	271	1,595	750	46	20.0	.004		32	244	201	594	1,500			
December	325	1,507		41	24.0	.001			143	216	522				
1917.															
January	306	1,357		53	12.0	.017		28	141	215	601				
February	289	1,339		44	10.0	.016		44	138	258	562				
March	515	1,647		51	8.6	.010			141	275	603				
April	566	1,534		45	5.8			24	40	240	368	913			
May	250	1,232		34	11.4	.008			184	257	597	1,333	1,533		
June	285			42	9.2	.005			210	243	618	1,060	1,400		
July	219			34	8.1				376	215	722	1,494	1,523		
August	214			27	4.8				160	153	468	833	1,020	796	355
September	233			37	4.8				198	208	267	896	1,290	14,819	10,191
October	182			56	7.8				323	222	189	1,124	1,600	8,900	4,537
Weighted average	279	1,709	814	49	15.5	.013	.001	32	226	283	675	1,062	1,338	10,843	7,213

[1] Averages for the days when waste was alkaline.

[2] Averages for the days when waste was acid.

The average analysis for May, in the preceding table, was obtained from the same number of determinations as that given for the Imhoff tank in Table 3. Comparing the results it is found that the suspended matter, residue on evaporation, turbidity, and nitrates of the Imhoff tank effluent were higher than the corresponding values for the septic tank effluent, while all the other results were higher for the latter. The only variations in the averages, however, that are greater than would be expected from samples of such strong wastes, collected from two different settling tanks, even of like design, are the suspended matter results. The septic tank removed, in the average for the month, 47 per cent more of this constituent than the Imhoff tank, and three of the four individual samples showed the former had a much higher removal. While only a few results are available for comparing the efficiency of the two tanks, nevertheless, it is believed that the data obtained show what can be anticipated from the operation of these two types of tanks. If surface baffles, similar to those in the septic tank, had been placed in the Imhoff tank there is no doubt that the latter would have given results much lower in suspended matter than were obtained. This subject is discussed fully in the conclusions.

The septic tank removed 46 per cent of the suspended matter in the raw waste and 47 per cent of the total solids. The figures represent, respectively, 238 and 1,529 p. p. m. Apparently, therefore, the tank effected the throwing into suspension and the removal of 1,291 p. p. m. of dissolved solids, or 2½ times the total amount of suspended solids present in the tank influent. There was no material change in the turbidity, the weighted average for all the results showing a reduction of 140 p. p. m. The organic nitrogen figures show a reduction from 84 to 50 p. p. m. and the free ammonia increased from 1.65 to 15.5 p. p. m. Nitrates were present in practically equal amounts in the raw waste and in the effluent of the tank in some of the samples for each month. Nitrates were found in only a very few samples of the raw waste and in a less number of samples from the septic tank. The alkalinity and acidity results of the raw waste and effluent of the tank varied so greatly in the composite samples that the weighted average gives only a very general idea of the reaction of the waste from day to day. The daily variations will be found in the tables in Appendix III. The tank effected a removal of 64 per cent of the material represented by the oxygen consumed determination. The oxygen demand of the raw waste was reduced in the tank by 4, 23, and 21 per cent, respectively, in the 24-hour, 5 and 10 day incubation periods. The oxygen demand results show that the nitrogenous organic matter was very much in excess of the carbonaceous, the oxygen consumed being only about one-half the 10-day oxygen demand in the raw waste and about one-fifth of that in the effluent of the tank. Of all the results given in the preceding table, those showing the actual amount of oxygen required to oxidize the organic matter are the most important when considered either from the standpoint of filtration or dilution in a receiving body of water. The bacteriological results of the tank effluent were approximately three and eight times higher than those of the raw wastes for the total count on agar at 30° C., and the red colonies on Endo plates, respectively.

A comparison of the tank effluents of creamery-waste-treatment plants is not only more feasible than the comparison of raw wastes but it is also of much greater importance. The key to the treatment of wastes of this character is oxidation. The character of the liquor to be oxidized is, therefore, the vital concern.

Table 5 contains analyses of the average tank effluent at Grove City, arranged for comparison with tank effluents at Sunbury, Ohio, and at a creamery in Wisconsin.

TABLE 5.—*Table showing average analysis of septic tank effluent at Grove City, Pa., compared with analyses of tank effluents at Sunbury, Ohio, and in Wisconsin.*

	Results in parts per million.									
	Suspended solids.	Residue on evaporation.	Nitrogen as—			Oxygen consumed.	Oxygen demand.			Acidity to phenolphthalein.
			Total organic.	Ammoniacal.	Nitrites.		24-hour.	5-day.	10-day.	
Grove City; average of 100 samples covering 200 days (wastes do not include condenser water, etc.)	279	1,709	50.0	15.5	.013	283	675	1,062	1,338	[1] 226
Sunbury, Ohio; average of 12 samples, Apr. 26–June 11, 1909 (wastes include condenser water, etc.) [2]	......	......	32.0	29.0	.000	94	......	......	......	771
Sunbury, Ohio; average of 8 samples, June 14–Aug. 5, 1909 (wastes do not include condenser water, etc.) [2]	......	......	87.5	85.0	.000	197	......	......	......	830
Sunbury, Ohio; average of 2 samples, Feb. 5 and Mar. 5, 1910 (wastes do not include condenser water, etc.) [2]	......	......	240.0	143.0	.0005	235	......	......	......	400
Sunbury, Ohio; sample taken and analyzed by United States Public Health Service, Nov. 10, 1916 (wastes do not include condenser water, etc.)	420	......	44.0	73.0	......	280	450	930	1,270	......
Wisconsin; average of 6 samples, July 17–27, 1907 (detention period in tank 24 hours) [3]	100	1,726	26.5	11.6	.000	136	......	......	......	......

[1] Days when waste was acid.
[2] From report of A. E. Kimberly, Ohio Public Health Journal, Vol. VII, No. 7, 1916.
[3] From article by J. T. B. Bowles, Eng. Record, vol. 64, p. 419, 1911.

While the results vary within a fairly wide range, it can be said that they fall within what might be called treatment limits; that is, while the ratio differences are large, the absolute values are not far enough apart to materially affect oxidation processes in subsequent treatment such as filtration.

It is noteworthy that the Grove City wastes results for organic nitrogen (with two exceptions) and for oxygen consumed are the maximum of the results given, indicating that the wastes are at least of average concentration. A remarkable similarity is found in the Grove City analysis and the analysis of the Sunbury sample taken November 10, 1916. With the exception of the free ammonia, the two samples are of equal strength.

The Wisconsin results are the weakest of all recorded, even including the Sunbury sample diluted by water from condensers, pasteurizers, and melting ice.

SAND FILTER NO. 1.

The effluent of the septic tank was applied to this filter throughout the period of the tests. During the summer time the waste was applied through a ¾-inch pipe so connected to the main feed line that it could be revolved about the bed and distribute the influent halfway between the center and the outside. In the wintertime the surface of the filter was furrowed and the waste applied at the center. A layer of straw about 6 inches thick was supported over the surface of the bed to prevent freezing.

The monthly average rates and the analyses of the influent and effluent of this filter, together with the weighted averages, are given in the following table:

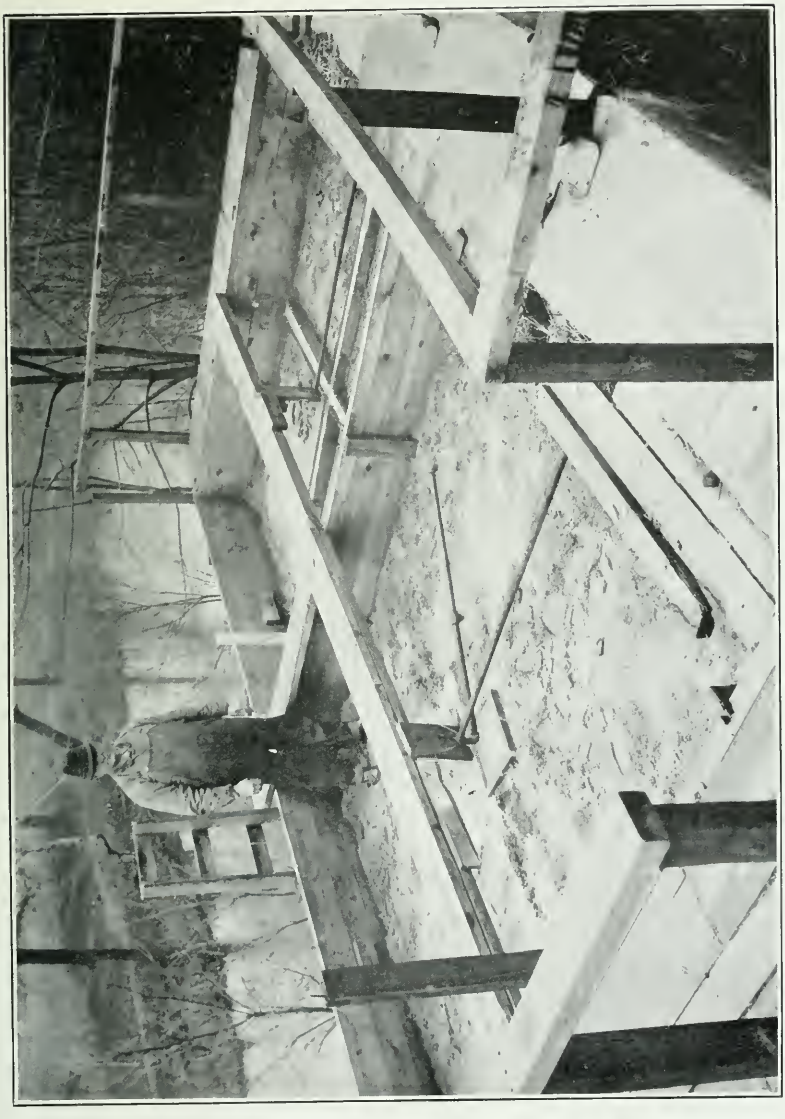

FIG. 4.—SAND FILTERS.

TABLE 6.

Monthly averages of chemical and bacteriological analyses of influent[1] to sand filter No. 1.

	Temperature, ° F.			Chemical analyses (p. p. m.)														Bacteria (1,000 per c. c.).	
	Influent.	Effluent.	Air.	Suspended solids.	Residue on evaporation.	Turbidity.	Nitrogen as—			Alkalinity.[2]	Acidity.[3]	Chlorides.	Ether soluble matter.	Oxygen consumed: 30 min. 96° C.	Oxygen demand at 20° C.			Agar 30° C., 48 hours.	Endo plates, red colonies.
							Total organic.	Ammoniacal.	Nitrites.						24 hours.	5 days.	10 days.		
1916.																			
May	75	58	56	237	2,636	652	106	17.7	0.055	....	631	....	....	1,402	2,610	....	....	....	....
June	....	....	....	230	2,516	775	115	20.8	.051	....	466	....	....	429	1,099	....	....	....	....
July	78	72	71	249	1,604	522	54	25.8	.010	....	191	....	....	232	951	....	....	....	....
August	76	68	63	276	1,755	1,019	57	22.9	....	....	166	....	....	236	669	....	....	....	....
September	72	61	59	329	2,101	1,071	44	27.3	.014	....	239	....	....	315	577	....	....	....	....
October	66	46	40	278	1,628	800	35	27.2	.008	....	40	....	....	182	508	....	....	....	....
November	63	42	39	271	1,595	750	46	20.0	.004	32	244	280	....	201	594	1,500	....	....	....
December	65	45	34	325	1,507	....	41	24.0	.001	....	143	305	....	216	522	....	....	....	....
1917.																			
January	65	38	27	306	1,357	....	53	12.0	.017	28	141	256	40	215	601	....	....	....	....
February	64	36	22	289	1,339	....	44	10.0	.016	44	138	....	82	258	563	....	....	....	....
March	66	40	33	515	1,647	....	51	8.6	.010	....	141	....	76	275	603	....	....	....	....
April	66	45	36	566	1,534	....	45	5.8	....	24	40	....	208	240	368	913	....	....	....
May	69	51	52	250	1,232	....	34	11.4	.008	....	184	....	30	257	597	1,333	1,533	....	....
June	75	67	66	285	....	....	42	9.2	.005	....	210	....	....	213	618	1,060	1,400	....	....
July	75	73	75	219	....	....	34	8.1	....	....	376	....	....	215	722	1,494	1,523	....	....
August	75	71	70	214	....	....	27	4.8	....	....	160	....	....	153	468	833	1,020	796	355
September	72	62	55	233	....	....	37	4.8	....	....	198	....	....	208	267	896	1,290	14,819	10,191
October	68	52	44	182	....	....	56	7.8	....	....	323	....	....	222	189	1,124	1,600	8,900	4,537
Weighted average.	70	55	50	279	1,709	814	50	15.5	.013	32	226	284	82	283	675	1,062	1,338	10,843	7,213

[1] Effluent of septic tank.

[2] Averages for the days when waste was alkaline.

[3] Averages for the days when waste was acid.

TABLE 6—Continued.

Monthly averages of chemical and bacteriological analyses of effluent of sand filter No. 1.

		Chemical analyses (p. p. m.).														Bacteria (1,000 per c. c.).	
	Net rate on filter G.A.D.	Suspended solids.	Residue on evaporation.	Turbidity.	Nitrogen as—				Alkalinity.	Diss. oxygen.		Oxygen consumed; 30 min. 96° C.	Oxygen demand at 20° C.				
					Total organic.	Ammoniacal.	Nitrites.	Nitrates.		P. P. M.	Per cent sat.		24 hours.	5 days.	10 days.	Agar 30° C., 48 hours.	Endo plates, red colonies.
1916.																	
May	22,900	10	1,720	20	7.00	49.00	14.000	7.0	185	3.4	33	64.0	51.0	....	....	....	....
July	22,800	7	3,292	10	.44	.16	.850	2.0	208	6.0	60	17.0	23.0	....	....	....	....
August	27,700	6	1,680	6	.39	.09	.330	45.7	355	5.2	57	8.0	4.0	....	....	....	....
September	30,300	6	1,348	7	.49	.05	.360	17.4	439	5.9	58	4.7	3.0	....	....	....	....
October	37,400	6	1,291	9	.42	.04	.035	17.4	360	9.3	80	6.1	2.4	....	....	....	....
November	44,800	5	1,033	3	.60	.08	.040	5.3	416	7.1	58	5.6	5.3	....	....	....	....
December	55,200	6	938	....	1.10	.10	.090	10.4	353	9.9	82	6.6	2.6	....	....	....	....
1917.																	
January	68,900	7	850	....	2.10	.09	.042	10.3	306	10.1	77	20.0	1.8	12.0	....	....	....
February	55,400	7	677	....	1.50	.08	.027	5.0	317	9.7	72	12.0	5.7	....	....	....	....
March	61,900	17	875	....	2.80	.16	.025	5.9	308	8.3	64	18.0	16.0	....	....	....	....
April	68,000	24	712	....	2.60	.24	.988	3.2	386	9.2	79	15.0	15.0	34.0	....	....	....
May	65,600	12	880	....	1.02	.30	.225	17.7	378	4.6	43	14.0	18.0	18.0	16.0	....	....
June	72,400	....	....	....	1.02	.40	.184	13.2	403	3.9	42	8.5	5.4	7.6	25.6	....	....
July	67,800	....	....	....	.90	.75	.095	21.0	290	3.3	37	11.0	2.8	24.0	32.0	....	....
August	78,200	5	....	....	1.00	.18	.095	18.5	400	5.1	58	4.4	1.3	18.5	36.0	42	9
September	80,900	30	....	....	.60	.04	....	6.2	427	6.8	69	5.1	2.9	13.1	20.6	129	75
October	53,200	....	....	....	1.70	.16	.012	1.7	386	5.6	50	7.5	21.0	26.7	43.0	242	55
Weighted average	55,800	9.8	1,175	9	1.33	1.72	1.244	15.5	362	6.4	60	11.6	7.3	17.9	31.7	109	45

As the results given for the temperature of the air and the influent and effluent are averages for the months and do not show the daily variations, attention is directed to the tables in the appendix for the daily readings, especially for the winter months. After the beds were covered with straw, the temperature was taken of the waste as it was discharged onto the bed. The covering over the tank and the filter permitted continuous operation through the coldest weather and nitrification continued active.

The suspended matter of the influent was reduced from 279 to 9.8 p. p. m., or a removal of 96 per cent. The residue on evaporation in the weighted average for the entire period was reduced by the filter from 1,709 to 1,175 p. p. m., this indicating that a part of the solids in solution were precipitated in the filter. During the six months that turbidity readings were made there was only one month when the average was as high as 20 p. p. m., all the remainder being 10 or lower. The total organic nitrogen was reduced from 50 to 1.333 p. p. m. These results are entirely satisfactory, and the monthly averages were uniform except for the month of May, 1916, when they were unusually high.

Nitrification was active throughout the entire period this filter was operated. There were some fluctuations among the monthly average results, and the individual samples showed still more, but at no time was nitrification reduced to such a point that the beds did not improve after a short period of rest or after some mechanical defect of the filter had been corrected. The low results for February, March, and April of 1917, were due entirely to stoppage in the underdrainage, resulting from settling of the foundation.

The reaction of the filtered effluent was continuously alkaline, and the conversion of 226 p. p. m. of acidity in the applied wastes to 362 p. p. m. of alkalinity in the effluent would indicate that bacterial action within the bed was normal at all times, and that whatever variation occurred in the results of the other determinations was due to unfavorable conditions in the underdrainage. If this were not the case, it is quite probably that the alkalinity results would have shown variations similar to the nitrates, oxygen consumed, and oxygen demand.

The per cent saturation of dissolved oxygen in the effluent was 60 for the weighted average, and the monthly averages ranged from 33 to 82 per cent. These results are in accord with the nitrates and nitrites as well as all the others already discussed, and show the high degree of purification that was effected by the filter. The weighted average result for the oxygen consumed shows that the effluent of the filter only had 4 per cent of the amount of material, measured by this determination, that was found in the influent.

With but a few exceptions, especially the month of May, 1916, the monthly average results for all determinations do not show any wide variations from the weighted average.

The oxygen demand of the influent was reduced in the filters by 99, 98, and 98 per cent, respectively, for the 24-hour, 5 and 10 day incubation periods. In this determination samples of the raw and treated waste are diluted with water of known oxygen content and incubated for the periods noted and the loss of oxygen determined. These results, therefore, show directly how much oxygen will be required from the stream or body of water receiving the waste. Knowing the minimum dilution available, a close approximation can be made regarding the effect raw or purified waste will have on entering any particular watercourse.

The putrescibility results reported as the number of hours required to reduce methylene blue at room temperature are not given in the table of the monthly averages, for the reason that samples were not stored for a longer period than six days, and monthly average results figured on this basis would fail to show the real significance of this determination. The detailed results can be found in the tables given in Appendix IV.

SAND FILTER NO. 2.

This filter was operated in parallel with No. 1. Except for a very short period at the beginning of the tests, each received the same influent. It was the original intention to apply the effluent from the Imhoff tank to sand filter No. 1, and the effluent from the septic tank to sand filter No. 2, but when the Imhoff tank became unserviceable it was necessary to use the effluent from the septic tank for both filters.

Data relating to the operation of this filter are given in the following table:

TABLE 7.

Monthly averages of chemical and bacteriological analyses of influent[1] to sand filter No. 2.

	Temperature, ° F.			Chemical analyses (p. p. m.).														Bacteria (1,000 per c. c.).	
	Influent.	Effluent.	Air.	Suspended solids.	Residue on evaporation.	Turbidity.	Nitrogen as—			Alkalinity.[2]	Acidity.[3]	Chlorides.	Ether soluble matter.	Oxygen consumed; 30 min. 96° C.	Oxygen demand at 20° C.			Agar 30° C., 48 hours.	Endo plates, red colonies.
							Total organic.	Ammoniacal.	Nitrites.						24 hours.	5 days.	10 days.		
1916.																			
May	74	59	56	237	2,636	652	106	17.7	0.055	....	634	....	....	1,402	2,610	....	....	....	....
June	72	64	63	230	2,516	775	115	20.8	.051	....	466	....	....	429	1,099	....	....	....	....
July	77	71	70	249	1,604	522	54	25.8	.010	....	191	....	....	232	951	....	....	....	....
August	77	70	63	276	1,755	1,019	57	22.9	....	....	166	....	....	236	669	....	....	....	....
September	72	62	57	329	2,101	1,071	44	27.3	.014	....	239	....	....	315	577	....	....	....	....
October	65	52	40	278	1,628	800	35	27.2	.008	....	40	....	....	182	508	....	....	....	....
November	61	38	33	271	1,595	750	46	20.0	.004	32	244	280	....	201	594	1,500	....	....	....
December	65	44	27	325	1,507	....	41	24.0	.001	....	143	305	....	216	522	....	....	....	....
1917.																			
January	66	38	26	306	1,357	....	53	12.0	.017	28	141	256	40	215	601	....	....	....	....
February	65	36	18	289	1,339	....	44	10.0	.016	44	138	....	82	258	562	....	....	....	....
March	67	40	33	515	1,647	....	51	8.6	.010	....	141	....	76	275	603	....	....	....	....
April	68	46	33	566	1,534	....	45	5.8	....	24	40	....	208	240	368	913	....	....	....
May	70	55	52	250	1,232	....	34	11.4	.008	....	184	....	30	257	597	1,333	1,533	....	....
June	75	67	66	285	....	....	42	9.2	.005	....	210	....	....	243	618	1,060	1,400	....	....
July	75	72	75	219	....	....	34	8.1	....	....	376	....	....	215	722	1,494	1,523	....	....
August	75	71	69	214	....	....	27	4.8	....	....	160	....	....	153	468	833	1,020	796	355
September	72	62	55	233	....	....	37	4.8	....	....	198	....	....	208	267	896	1,290	14,819	10,191
October	68	52	46	182	....	....	56	7.8	....	....	323	....	....	222	189	1,124	1,600	8,900	4,537
Weighted average	70	55	49	279	1,709	814	50	15.5	.013	32	226	284	82	283	675	1,062	1,338	10,843	7,213

[1] Effluent of septic tank.

[2] Averages for the days when waste was alkaline.

[3] Averages for the days when waste was acid.

TABLE 7—Continued.

Monthly averages of chemical and bacteriological analyses of effluent of sand filter No. 2.

	Net rate on filter G.A.D.	Chemical analyses (p. p. m.).														Bacteria (1,000 per c. c.).	
		Suspended solids.	Residue on evaporation.	Turbidity.	Nitrogen as—				Alkalinity.	Diss. oxygen.		Oxygen consumed; 30 min. 96° C.	Oxygen demand at 20° C.			Agar 30° C., 48 hours.	Endo plates, red colonies.
					Total organic.	Ammoniacal.	Nitrites.	Nitrates.		P. P. M.	Per cent sat.		24 hours.	5 days.	10 days.		
1916.																	
May	24,900	16	1,282	40	7.33	93.80	7.60	46.0	282	1.8	18	50.0	20.0	....	....	....	....
June	24,900	8	2,683	33	13.65	15.40	32.20	103.0	161	2.3	25	60.0	38.0	....	....	....	....
July	46,000	13	1,662	24	1.12	1.37	5.14	43.9	304	1.8	21	29.0	25.8	....	....	....	....
August	70,000	7	1,212	9	1.20	.29	.76	19.3	344	3.2	36	10.5	11.9	....	....	....	....
September	71,700	5	1,358	8	.27	.24	1.26	11.5	418	2.9	30	10.1	15.0	....	....	....	....
October	66,700	16	1,288	20	.63	.09	.15	12.5	340	6.9	59	8.8	3.9	....	....	....	....
November	61,800	17	1,133	5	1.22	.72	.27	11.5	299	8.8	71	9.5	47.0	30	....	....	....
December	63,000	4	1,011	....	1.21	.13	.07	6.8	352	9.5	79	6.2	5.3	....	....	....	....
1917.																	
January	76,600	15	924	....	1.62	.22	.18	4.4	382	8.5	65	11.6	21.3	....	....	....	....
February	39,300	29	797	....	2.56	1.77	.07	2.8	370	9.4	67	17.8	37.1	....	....	....	....
March	64,000	33	969	....	3.52	.86	.34	1.8	338	7.7	60	23.2	48.1	....	....	....	....
April	66,000	52	758	....	3.20	.15	.60	.2	439	6.8	59	35.0	33.6	88	....	....	....
May	60,000	28	836	....	4.42	6.69	.18	8.1	377	4.5	42	28.7	37.6	79	136	....	....
June	72,600	20	....	....	4.62	5.60	.60	22.1	422	2.7	28	13.1	24.3	54	142	....	....
July	65,500	32	....	....	2.38	1.50	.72	7.5	340	2.0	23	13.6	14.5	53	54	....	....
August	76,700	22	....	....	1.05	.80	.54	15.5	392	4.1	46	6.4	3.7	20	35	76	52
September	74,200	38	....	....	1.29	.10	.21	7.0	368	5.2	53	7.9	7.5	19	29	1,093	738
October	54,200	69	....	....	1.98	.20	.04	2.7	395	5.1	45	8.4	9.7	35	58	289	627
Weighted average	62,400	20	1,253	19	2.47	5.09	2.16	16.2	356	4.4	41	17.6	21.5	41	56	419	448

The rate of application of waste to this filter in the weighted average for the entire time the filter was operated was 62,400 gallons. For filter No. 1 it was 55,800 gallons, or about 10 per cent less. During the earlier months of operation No. 1 was purposely operated at a lower rate than No. 2 so as to insure a continuous operating record of at least one filter throughout the period of the tests in case No. 2 became unserviceable through overdosing. When filter No. 2 had been in operation for six months and there were no apparent signs of the rate being too high, the rate on No. 1 was gradually increased until the amount applied to both filters was approximately equal.

The effluent from filter No. 2 was not quite as satisfactory as that from No. 1, but, nevertheless, it was highly oxidized and stable practically all of the time. While it was not proved definitely that this filter was operated at the maximum rate of treatment for this class of waste, yet the difference in the quality of the effluents from the two filters would indicate very strongly that the maximum rate was nearly approached.

The suspended matter was twice that of filter No. 1, the residue on evaporation practically the same. As would be expected, the turbidity was a little more than double.

The organic nitrogen and free ammonia were considerably less in the effluent from filter No. 1, but the nitrites and nitrates were higher for filter No. 2. Referring to the tables in the appendix, it will be observed that nitrification was not more active in filter No. 2 than in No. 1, and that the higher averages for the values given were due to the results for June, 1916, for which there were no comparable figures for filter No. 1.

The alkalinity results were practically the same for both filters, and this fact would seem to indicate that filter No. 2 was not operated at an excessive rate, otherwise the bed would not have been able to convert the acidity of the influent to an alkaline reaction equal to that accomplished in No. 1.

The putrescibility results are recorded as the number of hours required to reduce methylene blue in samples stored at room temperature. These results, however, are not given in the monthly averages for the reason given under the discussion of similar results for filter No. 1. The detailed results are given in the tables in the appendix. Samples that maintained a blue color for six days are marked 144 hours and for those in which the color was reduced in a shorter time the actual number of hours is given. During cold weather, when bacterial action within the bed was lowest, there were some variations in the results and samples incubated at this time of the year did not always retain the blue color for the six days. There were, however, no odors in the samples incubated. The suspended matter of the filter effluent was low and, as will be observed, the oxygen demand was also low, so that no nuisance would have resulted from discharging the waste into any outlet, even in times of lowest efficiency of the bed.

The bacteriological results for filter No. 2 were higher than those for No. 1. These results, however, have no particular significance, as *B. coli* would be found in the effluent of any filter and sterilization would have to be carried out to eliminate this organism.

VOLUME, COMPOSITION, AND DISPOSAL OF SLUDGE.

VOLUME.

Only two measurements were made to show the amount of sludge that accumulated in the septic tank. In other similar investigations that have been made by this department in treating industrial waste, the accumulation of sludge has been determined at frequent intervals, but in these tests, owing to the necessity of keeping the septic tank in these tests covered, it was not practicable to make frequent measurements.

After the plant had been in operation for about six months there were found in the tank 1.47 cubic yards of sludge on the bottom and 0.44 cubic yard of scum at the surface. During this period 87,000 gallons of waste passed through the tank. Computed on the basis of the amount per million gallons, there were 16.9 and 5.1 cubic yards, respectively, for the sludge and the scum. The per cent moisture and specific gravity of the sludge and scum were, respectively, 94.8 and 1.013, and 78 and 1. Figured on a dry basis and including both the sludge and the scum, there was an accumulation at the rate of 1.7 tons dry solids per million gallons of waste.

A second measurement was made of the sludge 11 months after the one referred to above. During this period 438,500 gallons of waste passed through the tank, and there were deposited 3 cubic yards of sludge at the bottom of the tank and 4.4 cubic yards of scum at the surface. Sludge and scum were therefore deposited at the rate of 6.84 and 10 cubic yards per 1,000,000 gallons of waste.

These figures show considerable variation from those obtained in the first measurements. At the close of the first period the relation of the volume of the scum to the sludge was approximately 1 to 3, while at the end of the second period the ratio was reversed and the amount of scum was about twice that of the sludge. The concentration of the sludge had some bearing on this change of relation, but the most probable reason for the large amount of scum accumulation during the later period was the fact that it covered one full summer season, when the temperature of the waste is conducive to scum formation.

Computing the solids found in the tank in the last measurements to a dry basis, there was a total of 2.3 tons deposited per 1,000,000 gallons of waste treated. This figure agrees closely enough with the value similarly computed for the first measurements to assume that approximately 2 tons of dry solids per 1,000,000 gallons of waste can be expected in a tank treating this type of waste. It would also seem safe to predict that about 20 cubic yards of wet sludge will have to be disposed of for each 1,000,000 gallons of waste passing through tanks. If tanks are designed with sufficient storage capacity for sludge and scum to permit operation without cleaning for a period of one year or more, it is quite probable the concentration of the scum and sludge will be such that a smaller quantity than 20 cubic yards per 1,000,000 gallons of waste will require removal.

A theoretical method of approximating sludge deposition is computing its volume from analysis of suspended solids in the influent and effluent of the tank. By this method the deposition to be expected amounts to but 1 ton per 1,000,000 gallons, as compared with 2 tons figured on actual sludge measurements.

Such figures would almost seem to indicate that the volume based on sludge measurements is in error, exceeding the correct figure by 100 per cent. Such a conclusion, while possibly justifiable with sewage and many industrial wastes, could not be correctly applied to creamery wastes.

As already pointed out, the difference in the suspended solids contents of the influent and effluent of the tank does not correctly indicate the actual removal of solids by the tank. The suspended solids in the waste as it enters the tank are greatly increased by the souring action within the tank, whereby much of the dissolved solids content is precipitated.

Computing the deposition on the basis of total solids removed, which takes into consideration the dissolved solids precipitated in the tank, completely reverses the ratio found above and gives a computed deposition of 5 tons dry solids per 1,000,000 gallons as compared with the measured deposition of but 2 tons.

No explanation of these differences is offered, though the factor of volatilization should not be overlooked. In conclusion, however, it should be stated that when the sludge accumulation was actually handled it was evident that the figure of 2 tons of dry solids per 1,000,000 gallons was approximately correct. Moreover, a deposition of 5 tons would have completely filled the septic tank, a condition which did not exist.

COMPOSITION.

It was realized at the time the first measurements of sludge and scum were made that the odors and the comparatively small volume would prevent the use of this material either as a commercial fertilizer or as a means of recovering fats.

In Table 8 are given certain data relating to the volume and composition of the scum and sludge deposited in the septic tank.

The organic nitrogen was high enough to justify farmers in hauling the sludge and scum for use as a fertilizer on land if it could be applied in sufficient quantity, but the high fat content would prohibit the use of a sufficient amount on a given area to obtain returns commensurate with the time and labor involved in hauling the material to the farms and distributing it. In the scum there was found 59 per cent of ether-soluble material, which is considered as fat, and there was 9.5 per cent in the sludge. These quantities are so far in excess of that permissible in fertilizers that applying the solids removed from dairy products wastes to land must be considered simply as a means of disposal rather than as fertilization.

TABLE 8.—*Table showing the volume and analysis of sludge and scum from the septic tank.*

Period covered.	Sludge and scum accumulated.													
	Deposited (cubic yards).		Waste treated (gallons).	Deposited (cubic yards per million gallons).		Analysis.								
						Per cent water.		Specific gravity.		Per cent nitrogen.		Per cent ether soluble matter.		Deposited (tons dry solids per million gallons).
	Sludge.	Scum.		Sludge.	Scum.	Sludge.	Scum.	Sludge.	Scum.	Sludge.	Scum.	Sludge.	Scum.	
Dec. 1, 1915, to May 23, 1916	1.47	0.44	87,000	16.9	5.1	94.8	78.0	1.013	1.000	....	....	....	....	1.7
May 24, 1916, to Apr. 6, 1917	3.0	4.9	438,500	6.84	10.0	92.5	78.0	1.009	1.000	3.0	1.24	9.5	59	2.3

The analyses given in Table 8 were obtained from scum and sludge freshly drawn from the septic tank. A small portion of this sludge was air dried and sent to the Cincinnati laboratory for complete analysis. For the purpose of comparing the composition of this sludge with that from another creamery, a sample of air-dried sludge was obtained from the Sunbury Cooperative Creamery Co., at Sunbury, Ohio, and analyzed. The following table gives the analyses of these two sludges:

Table 9.—*Table showing analyses of air-dried sludge from the Sunbury Cooperative Creamery Co. and the testing station at Grove City Creamery Co.*

Date.	Source.	Per cent ash.	Per cent dry basis (100° C.).							Per cent Silica (SiO_2) in ash.
			Moisture.	Nitrogen.	Ether-soluble matter (fats).	Calcium as CaO.	Potassium as K_2O.	Phosphorus as P_2O_5.	Iron as Fe.	
November 11, 1916	Sunbury	36.6	33.5	1.51	35	4.07	0.14	1.28	1.9	62.3
November 10, 1917	Grove City	10.8	83.9	2.00	43	6.40	.80	1.40	2.6	61.1

The sample obtained from the Sunbury Cooperative Creamery was taken from a pile of sludge and scum that had been lying in the open for some time. An attempt was made to get a sample free of foreign material, but it is quite possible there was a small amount of soil mixed with it. The sample from Grove City, however, was air-dried, and there was no opportunity for foreign substances to get into it.

The difference in the moisture of the two samples is an index of the length of time each sample was dried. At Grove City the sludge and scum were dried to about the consistency that would occur in the ordinary period of drying on sludge beds while that at Sunbury had been exposed to the sun a sufficient length of time to reduce the moisture as low as it would go.

Apparently the exposure to the sun has no effect on the composition of the scum and sludge. All of the results of the different determinations, except the per cent ash, are so nearly alike for the two samples as to warrant the conclusion that but little change takes place in either the scum or sludge within the first few months after being drawn from the septic tank, even when exposed to the sun in the summer time. Moreover, the analyses of the wet scum and sludge as removed from the tanks do not show any wide variations over the same material when dried in the air. In table 8 the analysis of the wet sludge and scum showed 3 and 1.24 per cent, respectively, for the organic nitrogen, the average being about 2 per cent, and this is the same figure for the dried sample. In a similar comparison of the fats the dried sludge showed higher results, but the difference can be readily accounted for in the proportion the scum and sludge bore to each other in the air-dried sample. With a 59 per cent scum and a 9.5 per cent sludge a slight variation in the mixture ratio effects a marked difference in the composite.

The one exception to the general agreement of the results of analyses from the two dried samples of sludge is the per cent ash. The Grove City sludge had 10.8 per cent ash, while that from Sunbury had more than three times as much, or 36.6 per cent. These figures were checked by reanalysis several months after the first analyses were made, and the agreement was so close as to admit of no other interpretation than that one sample had more than three times as much ash as the other. The determination has, however, no particular significance, except as showing that such a difference may exist where all the rest of the constituents agree closely. The other organic constituents are a shade higher in the Grove City results, and it is possible that enough soil became mixed with the Sunbury samples to materially affect the per cent ash while affecting the other results to only a slight degree.

The amount of fat reported in all the analyses would seem to be sufficient to warrant recovery. The fatty material, however, when deposited in the tank either in the form of scum or sludge undergoes decomposition that renders it practically worthless as a salable product. It can not be renovated and used as butter fat, because the composition has been changed, and if extracted as an ordinary grease the total quantity would not be enough to justify the expense.

DISPOSAL OF THE SLUDGE.

In a preceding paragraph, relating to the volume and composition of the sludge, particular reference was made to odors and the grease content of the scum. These are the factors that control the possible means of disposal of the solids removed from the waste. Sludge from sewage and practically all industrial wastes can be dried on suitable beds located near the disposal plants and the dried residue hauled away for fill or for use as a fertilizer on land. The peculiar strong odor from creamery waste sludge, however, prevents the adoption of this method. On account of the comparatively small volume of waste from the dairy products industry and the consequent small amount of solids to be disposed of, it is not so essential to carry out dewatering processes at the treatment plants for these wastes as it is for those plants purifying domestic sewage and many other industrial wastes.

The only practicable methods, therefore, that remain for disposing of creamery waste sludge is either to haul it away from the treatment plant and deposit it on land or bury it in shallow trenches near the disposal plant. This should be done in the fall of the year after fly season is over, and the land selected should, preferably, be that which is to be plowed the following spring. If it is desired to utilize land near the creamery or near dwellings, furrows can be made by an ordinary "breaking plow" and the wet scum and sludge applied to the furrows and covered with a few inches of loose earth to prevent the rise of odors until the material applied has had time to dry out.

SUMMARY AND CONCLUSIONS.

A testing station was operated at the Grove City Creamery from December, 1915, to October, 1917. During this time the volume and composition of the raw waste were determined, and certain devices, commonly used in sewage purification, were utilized to treat the waste. It is believed that the tests were conducted for a sufficient length of time and that the results were satisfactory enough to justify rather definite recommendations as to the type of plant best suited for treating creamery waste of the kind produced at the Grove City Creamery Co. It is probably true that modifications of the type of plant recommended will be found desirable, as more information is obtained in the operation of full-size plants and changes will be required to meet certain local conditions. The essential principles, however, were so thoroughly demonstrated in the tests that creameries and other dairy products manufacturers can install treatment plants with considerable more assurance of getting satisfactory results than was possible heretofore. The type of treatment plant recommended is neither novel nor new, but it has been tried out and found satisfactory, and plants of apparently the same type as recommended in this report which have not operated successfully have, it is believed, neglected to incorporate some essential feature which is covered in these recommendations which include intelligent supervision of operation.

This report may, therefore, be considered as a study undertaken for the purpose of developing a method for purifying creamery waste, in the course of which it was found that methods already in use were efficient and practical in only a very few instances and very unsatisfactory in a large number of other installations. The problem, therefore, became one of finding out what the essential features of design were, of obtaining data relating to the volume and composition of the waste, and of recording them in such manner as to be readily available for the dairy products industry.

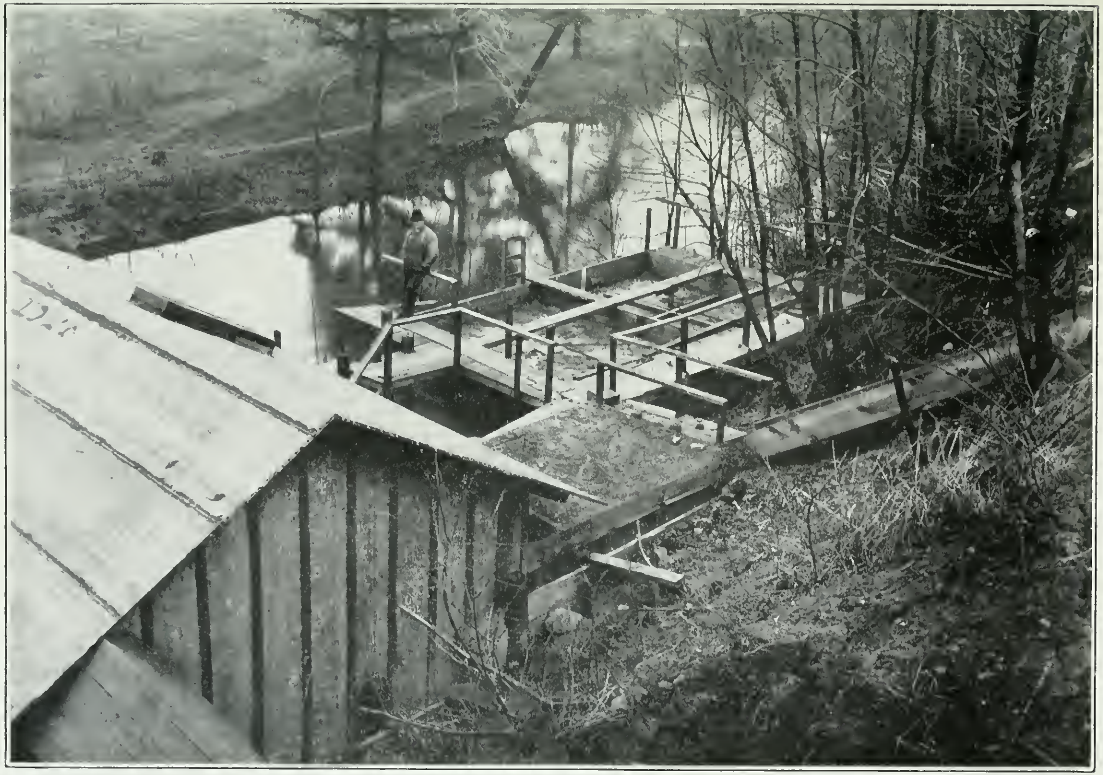

FIG. 5.—BIRD'S-EYE VIEW OF TESTING STATION.

CHARACTER AND VOLUME OF THE RAW WASTE.

The raw waste treated in the testing station was produced from the manufacture of butter, cottage cheese, casein, and condensed milk. The term "waste" is used here to include only such liquids as resulted from washing apparatus, utensils, the floors, from laboratory operation, including testing acids, and waste from the toilet rooms and lavatory. There was no whey, buttermilk, or skimmed milk included, and the condensing and cooling waters were discharged into a creek direct. It must be quite obvious that if whey, buttermilk, or skimmed milk are discharged into the waste to be treated the amount will vary with each individual creamery, and that no form of treatment plant could be recommended that would be elastic enough to cover the wide range of possibilities. On the other hand, the wastes treated in the tests were very concentrated, as was shown in the tables of analysis, and they are common, in volume and composition, to a large per cent of the various plants making dairy products.

It is believed that the waste treated in the tests was as concentrated as any of those for which analyses are given in the various other reports. Looking over the analyses of the individual raw waste samples in the appendix, there will be found many results considerably higher than any reported from other sources. An apparent reason why special samples of an industrial waste or sewage often show higher results than the average for a long period is the fact that the special samples are ordinarily taken during the busy season when the waste is causing a nuisance. Attention is, therefore, called to the results in the appendix in order that the daily and seasonal variation of the strength of the raw wastes may be studied.

There is probably more opportunity for error in taking samples of raw wastes from the dairy industry than from any other industry, and the chances of variations in analysis of samples from the same source are even greater, due to the fact that cream and pieces of butter, as well as other foreign material covered with grease, float, making it difficult to obtain representative samples. The rapidity with which scouring takes place may introduce apparent errors in the analysis of samples from the same source, but collected under only slightly different conditions.

To reduce the possibility of such errors in the tests, the raw waste samples were collected at the end of the sewer which discharged the waste into the weir boxes of the testing station, and the samples were sterilized according to the very strict routine already described.

SEDIMENTATION.

When the plans for the testing station were prepared designs were included for an Imhoff tank and a septic tank. A description of these tanks has been given in an earlier chapter of this report, where it was stated that they were constructed of wood and that considerable trouble was experienced in making them water-tight. They were placed in operation early in December, 1915, but in May, 1916, it was necessary to abandon the Imhoff tank on account of the odors from the wastes leaking through the bottom. The septic tank also leaked badly at the start, and more or less trouble was experienced from this source throughout the entire time the tests were run, but after the first few months the leakage was not sufficient to cause the tank to be abandoned.

Imhoff tank.—The difficulties encountered in operating this tank, which finally led to abandoning it, have already been described. These, however, had no bearing or relation to the efficiency of this type of tank as compared with any other form of settling tank, and the discussion that follows refers solely to the action of the waste within the tank.

The advantages that have been claimed for the Imhoff tank are that the suspended matter, settling out of the waste or sewage passing through the tank, drops between baffles so arranged that when this suspended matter undergoes decomposition as sludge and rises, due to the formation of gas, it can not come in contact with the waste or sewage flowing through the tank, but rises to a so-called gas or scum section. The claims for this type of tank have been justified in treating domestic sewage and wastes where there is active decomposition of the sludge, with the consequent rising of suspended particles borne up by small bubbles of gas and where no radical change takes place in the soluble organic matter in the wastes entering the tank. Under these conditions the suspended matter of sewage and wastes is effectively removed, and the liquid part of the influent is practically unchanged in passing through the tank and is not affected by the decomposition that takes place in the sludge.

In treating creamery waste or any other dairy products waste two factors enter, which to a very large extent nullify the advantage claimed for the Imhoff tank. These refer to the greasy nature of the suspended particles and the souring of the wastes after entering the tank whereby suspended matter is formed. The organic matter in the raw wastes either consists of butter fat or is coated with it, and does not readily settle in any form of tank, and the curd formed by souring of the waste in the tank also rises to the surface and remains as scum. It becomes evident, therefore, that the flow section of an Imhoff tank will accumulate scum to practically the same extent as would any other design of tank. Observations at the testing station indicated, furthermore, that there was but little gas ebulition from the sludge in the bottom of the tank, and that the gas section was of no particular advantage.

It is realized that the Imhoff tank was not in operation for a long enough period of time to warrant a positive statement that the advantages of this type of tank are not realized in the treatment of creamery waste, but all the evidence pointed so strongly that way that it is believed that longer experience with the tank would only have verified the conclusions given above.

It has been proposed that the Imhoff tank principle be used in combination with the septic tank for the purpose of removing the suspended matter carried over by the effluent from the septic tank, but it is believed that the same objections offered to the use of the Imhoff tank alone will hold in this combination. The suspended matter in the effluent of any tank treating creamery or like wastes will consist of particles of grease or grease-covered matter that will not settle, and, therefore, it would appear that an Imhoff tank following a septic tank would be of no more service than another septic tank of equal capacity.

Septic tank.—A tank of this design was operated for about two years, and many analyses made of the effluent. There were also some analyses made of the sludge deposited in the tank.

A comparison of the weighted average analyses of the influent and effluent for the entire time the tank was operated shows that 46 per cent of the suspended matter in the raw waste was deposited in the tank. This figure, however, does not show the true amount of suspended solids that was deposited, as the souring of the waste in the tank caused the formation of an additional amount that does not show in the per cent removal given above. The effect that souring of the waste in the tank had on the volume of sludge deposited in the tank has been shown in comparing the tons per 1,000,000 gallons of dry sludge computed from the amount of sludge measured in the tank, and the amount computed from the difference between the weighted averages of the suspended matter in the influent and effluent of the tank.

The septic tank did not accomplish as high a removal of the various constituents of the raw waste as was expected and not as much as, it is believed, can be accomplished by a longer detention period in the tank and by a different arrangement of the baffling. This subject is discussed in detail under the heading "Plant recommended."

The tank was not provided with a tight cover at the beginning of the tests, but this became necessary the spring following the first winter after the plant was placed in operation. This experience suggests the necessity of locating septic tanks and filters as far away as practical from the creamery or other like plants or from dwellings and other buildings where people live or work. There are many septic tanks in operation at this time that are not producing odors and it is believed that ordinarily there will not be any appreciable odors after the first year of operation, but, as a matter of precaution, tanks should be located at least 200 yards away from places where people live or work.

FILTRATION.

Sand filters.—In the original design for the testing station two sand filters were included, one for treating the effluent from the Imhoff tank and the other for the effluent of the septic tank. As the Imhoff tank was operated only irregularly during the short time it was in service, the sand filter installed for treating this effluent was in operation only a few days between the time the testing station was started and May, 1916, when the Imhoff tank was abandoned. This filter will be designated as No. 1. Filter No. 2, used in combination with the septic tank, was operated throughout the period of the tests and was, therefore, in operation about five months longer than No. 1. When the Imhoff tank was discontinued, filter No. 1 also received the effluent from the septic tank and was operated in parallel with No. 2.

The two sand filters were installed primarily to learn whether the combination of tank treatment with filtration of the effluent through sand would produce satisfactory effluents continuously, and, secondarily, to determine whether the Imhoff or septic tanks would best prepare the waste for filtration. Both filters were, therefore, constructed alike in every detail.

There were no particular precautions taken in placing the sand, except that the first sand thrown into the bed was carefully placed over one small section, and additional sand, sufficient to cover the underdrainage to a depth of about 1 foot, was thrown onto this small section and then spread over the entire surface. It is important that this procedure be followed as throwing the sand, especially from any considerable height or distance, may force it through the top layer of the underdrainage and permit it eventually to reach the bottom of the filter.

The effective size of the sand used in the two filters was 0.23 mm., and the uniformity coefficient was 2.17. It is believed, however, that there is a considerable wide variation in the size of the sand that will give satisfactory results. Sand that is too fine, like sea sand, will clog quickly and cause considerable trouble from the operation standpoint, but the effluent would no doubt be excellent. On the other hand, sand that is too coarse will permit the waste to pass through the bed too quickly and the effluent will not be thoroughly oxidized.

It is important that the sand be washed free from clay or loam and all other foreign substances.

Both filters were operated at low rates when first placed in operation, No. 1, however, being operated at a lower rate for a longer period of time than No. 2. By this means the efficiency and rates of the filters were worked up to the maximum gradually, and, by daily observations and frequent analyses, it was possible to determine the maximum efficiency and rates before the beds became overworked to a damaging degree. Starting with rates of 25,000 gallons per acre daily, the rates on both filters were gradually worked up to approximately 75,000 gallons for the last few months of the tests. As, however, these filters were under constant supervision and were given attention that would not be possible at creameries or other dairy products plants, it is not believed that the higher rates should be used in computing the filter area required for disposal plants where no technical supervision is possible. It does seem reasonable, however, that a rate of 50,000 gallons per acre daily can be used as a basis for determining the area of filter surface required, and that on this basis the attention the filters will require will not be a burden.

The wastes were applied to the filters, during the major portion of the tests, through two openings in a small pipe which was attached to and swung freely from the feed pipe, which extended to the center of the beds. The openings were in the middle and outer end of the small pipe which was revolved about the bed according to a definite schedule so as to give an approximately equal amount of waste to each unit of the surface. On the average, the distributing pipe was moved to different positions three times each day. For a short period all the waste applied to the filters was discharged continuously onto a board 1 foot square placed in the center of the bed. This was not satisfactory, however, as only a small area of the bed received waste at one time. When the waste was first applied to the board in the center it filtered through the sand next to the board until it clogged and then it flowed to a circular area just beyond the board and so on until the entire bed was covered. By the time the entire surface of the bed had been utilized the center had been covered continuously for several days and this no doubt interfered with oxidation within the central portion of the bed.

On December 9, 1916, a straw covering was suspended 6 inches above the surface of the beds and the waste was applied to the center of the filters and distributed by means of furrows radiating from the center. At the end of one and one-half months, when the filters were examined, the waste stood to about mid depth of the furrows and the effluents of the two filters were not satisfactory. The furrows were then leveled (Jan. 22) without removing the straw covering and the filters operated by applying the wastes to a board at the center of the filters, as described above, until March 13, when the straw was removed.

It was not anticipated that the filters thus covered would produce effluents equal to that from the filters when they were uncovered, but it was realized that the filters could not be operated without some protection during severe winter weather, and covering them was the only alternative. The volume of the waste applied to the filters was not sufficient to take advantage of the principle, often used with sewage filters, of flooding the furrows and thus allowing the ice formed across the top to serve as a cover for each furrow.

While the effluents from the filters were not entirely satisfactory during the wintertime, they were a very decided improvement (see tables in appendix) over the effluent from the septic tank. Even with the lowered efficiency of the filters in the wintertime it is doubtful whether a nuisance would have been created even under the most unfavorable conditions as to the places of discharge, since the bacterial activity necessary to produce such nuisance is so lowered during cold weather that nuisances from this source seldom exist. There was no suspended matter in the effluent from the filters to cause deposits that might decompose with the return of warm weather.

It is believed that it would be entirely justifiable in many locations to by-pass the sand filters during the wintertime. The wastes should, however, be passed through septic tanks in order to remove the larger part of the suspended matter that may accumulate near the outlet or form sludge banks along the water course that might become very offensive in hot weather.

The straw covering that was placed over the filters consisted of about 1 foot of loose straw supported about 6 inches above the filters by wires stretched across the top of the beds. The wires were stretched from two sides of the filters at right angles to each other and spaced so as to form squares of about 20 inches. The straw was first placed over the wires where they crossed each other and the whole space tied in, with the straw resting on the cross-wires. Where filters are designed to be operated during the wintertime, posts should be set in the beds, projecting above the surface, to serve as supports for any type of covering that may be selected. If straw is used, care should be exercised in removing as much chaff as possible, and considerable attention should be given to removing all straw and chaff from the surface of the bed when the covering is taken off in the spring.

The methods used for applying the settled waste to the filters were satisfactory and were possible only because of the attention that could be given to the operation of the testing station. In large installations treating the entire wastes from a creamery or other dairy products plants it will be necessary to use automatic siphons, and it is believed that filters dosed with wastes by this method will give as satisfactory results as were obtained in the tests; in fact, they may give even better results, since the influent will be evenly distributed over the entire bed, whereas in the tests only a small section of the bed was receiving waste at any one time.

The amount of waste to be applied to a filter at each discharge of the siphon is usually determined by the depth that it is desired to apply over the entire area. If it is intended to apply the dose in the filter to a depth of 1 inch, either the size of the bed or siphon chamber is designed to hold or draw enough waste to cover the surface of the filter to this depth. For the purpose of designing the filters and installing the siphon it is recommended that one-half inch be considered as the dose to apply at the time of each discharge of the siphon.

There are several reasons for recommending the shallow flooding depth. In the first place the waste will disappear more quickly from the surface of the bed and there will be less danger of odors arising from decomposition of the wastes exposed to the sun. In the second place the surface of the bed will be exposed to the sun and light more if dosed lightly, even though oftener, than will be the case if larger doses are applied. The reason for this is that the sun and light preventh growths from forming with the shallow dosage, and these same agencies tend to keep the surface sand from getting hard and packed when the bed is exposed oftener, as will be the case with an application of a small dose. Another reason for applying small doses to the filters is that the beds become practically sealed up when the wastes are first applied, and if the waste remains over the surface for any length of time aeration of the bed will be practically stopped.

If the filter beds are designed for receiving doses equal to a depth of one-half inch over the sand the beds should be arranged in small units and the influent coming from the siphon chamber should be divided at the filters, a part going to each small unit. Should it be desired to use large units, laterals laid over the sand and supported on concrete posts should be installed and dash plates laid under the discharge end to prevent pooling in the holes washed by the discharge of the waste. It is believed that the best results will be obtained by bringing one lateral to the center of each 400 square feet of filter area and providing for a dose that theoretically would cover this area to a depth of one-half inch.

The essential features, therefore, that ought to be considered in designing sand filters for treating creamery wastes are as follows: First, the underdrainage should be carefully laid with ample slope to the bottom and covered with coarse and fine stone so arranged as to prevent the sand from getting through and forming dams on the bottom either among the stone or in the tile; second, the sand selected should be of medium size and free of clay and loam or any other substance that will tend to mat the sand grains together and retard the flow of the waste through the bed: third, a number of doses is preferable to one large application, and the units should be arranged accordingly: fourth, filter beds should be divided into at least two units so that one can be taken out of service for the purpose of resting or repairs: fifth, unless the treatment plant will be under competent and constant supervision the filters should be designed to treat the wastes at a rate not to exceed 50,000 gallons per acre per day, and the maximum volume of wastes produced or likely to be produced from any manufacturing plant should be used as the basis for computing the filter area required.

SLUDGE.

Owing to the fact that the septic tank was covered and it was not deemed feasible to remove the covers for measuring the sludge at the end of each month, as has been the practice in similar studies with other industrial wastes, only two measurements of the sludge and scum in each tank were made. These showed an average deposition at the rate of 2 tons of dry solids per 1,000,000 gallons of waste passing through a tank. Similar data figured from the difference between the suspended matter in the influent and effluent indicate that but 1 ton should have been formed. The difference was probably due to soluble material in the influent that was precipitated in the tank.

The total solids in the influent and effluent were determined, but the results showed a higher removal in the tanks than it was possible to obtain. That is, the tank would have been entirely filled with sludge at the close of the tests if all the solids had been deposited at the rate indicated by the total solids determinations. This, however, was not the case. There were a large number of analyses made of the total solids and suspended matter in the influent and effluent, in fact the same number of determinations were made and the same composite samples were used for each of the analyses. Both methods are subject to the same degree of accuracy. The measurements of the sludge in the tank can be made with a fair degree of accuracy and the same may be said in regard to the analysis of the sludge. It is, therefore, not a simple matter to explain why the total solids showed values so entirely out of proportion to the amount of sludge found by the other two methods. The sludge actually measured in the tank was taken as the basis for computing the probable quantity of sludge that can be expected from creamery or similar dairy wastes.

The chemical analyses of the sludge showed that it was similar in composition to that from at least one other creamery. The results also indicated that the sludge produced from this type of waste contains no valuable by-products and that it has no high-grade fertilizer value.

No attempt was made to dry the sludge at the testing station. The creamery was located less than 100 yards away and the offensive odors given off from the sludge prevented this study. The amount of sludge from the wastes of a creamery in one year will not be large in amount, so that it will be practical to haul the sludge away from a treatment plant and either bury it or scatter it over land where the odors will not become a nuisance.

PLANT RECOMMENDED.

The testing station was operated two years, and during this time but few changes were made in the various devices as originally installed. The results obtained were satisfactory practically all of the time, and it is believed that the devices which will be recommended and described in detail in the following paragraphs will give more uniformly satisfactory results than were obtained in the tests. This is to be expected, since a thorough study of the chemical analyses and bacteriological results, together with the operation data, for the whole period of operation was sure to reveal changes that should have been made in the design of the various devices, but could not be appreciated while the tests were in progress.

PUMPING EQUIPMENT.

Pumping will be required where the difference in elevation between the discharge of the waste at the disposal site and the outlet into the watercourse is less than 7 feet. A centrifugal pump and automatic-control device worked very satisfactorily in the tests, and, where pumping is required, it is recommended that such equipment be used.

SEPTIC TANK.

Detention period.—The detention period of the wastes in the tank at the testing station was approximately 24 hours, and this was sufficient so far as preparing the waste for oxidation on sand filters was concerned. It was not, however, sufficient to remove as large a part of the suspended matter as it is believed can be accomplished, and not as much as ought to be removed to permit long periods of operation of the filters without cleaning. It is proposed, therefore, that tanks designed for treating creamery or like wastes be computed on a storage basis of 48 hours, with 30 per cent additional for scum and sludge accumulations. On this basis a creamery producing a maximum of 1,500 gallons of waste per day would require a tank with a net working capacity below the outlet of the tank equal to 3,900 gallons.

Construction of tank.—As suggested in the preceding paragraph, the principal concern in constructing the tank is to design it to retain the largest amount of suspended matter. For this purpose it is recommended that the tank be divided into two sections separated by a concrete wall with ten 2-inch holes through it at mid depth of the waste. The inlet section should have a capacity of two-thirds of the volume of the entire tank and the outlet section one-third. The inlet section should contain at least three baffles, one 1 foot from the inlet pipe and extending from above the surface of the waste to 3 feet below, one 1 foot in front of the outlet and conforming to the one before the inlet, one in the center of the tank extending up one-half the distance from the top of the hopper bottom to the flow line of the tank. If there should be more than one hopper bottom, baffles should be placed between each two hoppers and additional surface baffles installed at intervals of 8 feet. It is assumed that if only one hopper is built the tank will not be over 10 or 12 feet in length. The outlet of the tank, connected with the inlet section by means of ten 2-inch holes through the wall, need not contain a hopper bottom if this section is less than 4 feet in length, but it should contain a sludge outlet pipe. With this length (4 feet) there should be three wooden baffles extending from above the surface of the wastes to a depth of at least 6 feet. The baffle next to the outlet, set 1 foot back, should have at least 50 one-half-inch holes bored through it, and the other two with a like number of 1-inch holes in them. The top row of holes in each baffle should be 18 inches below the outlet from the tank and the bottom row 1 foot from the bottom of the baffle. Should the outlet section be longer than 4 feet the baffles could be placed 18 inches apart and the ratio of the baffles with the one-half inch to those with 1-inch holes be 1 to 2, those with the smaller holes following those with the larger. The purpose of these baffles is to act as colloiders in collecting the fine particles of suspended matter carried in from the inlet section. If the outlet section is of greater length than 4 feet, a hopper bottom and sludge outlet pipe should be installed.

The hopper bottoms should have a slope of 60°, and sludge outlet pipes should be 6 inches in diameter with the inlet ends resting over the center of the hoppers and 8 inches above the bottom.

The tank as a whole should either be designed with a tight concrete top or provision made for placing a tight wooden cover should the necessity for it arise.

If a concrete cover is installed, openings extending across the tank and 2 feet wide should be left over each baffle and over the partition wall separating the inlet and outlet sections. Provision should be made, however, for placing wooden covers over these open sections if needed. The purpose of these openings is to permit inspection of the inside of the tank and to remove scum from the surface if it ever should seem desirable to remove it in this manner. This requirement for tanks under 12 feet long will practically necessitate a removable cover for the entire tank.

The inlet and outlet pipes to and from the tank should be turned down and trapped. This will prevent flies from getting to the scum and also the escape from the scum of odors which may not be in the liquid waste. In the tank at the testing station the odors above the scum were much stronger than those from the waste coming from the tank.

SIPHON CHAMBERS.

On account of the small size of the filters (10 by 12 feet) used in the tests, siphons were not installed. They should, however, be installed in connection with disposal plants treating all the wastes from a creamery or other dairy-products industry. It is recommended that the siphon chamber or chambers be designed so as to discharge enough waste each time to cover the sand filters to a depth of one-half inch. Provision should be made for covering the siphon chamber in a manner similar to the tanks.

SAND FILTERS.

Underdrainage.—It is very essential that the underdrainage be carefully prepared. The earth should be excavated for each unit of 400 square feet to an approximate depth of 4.5 feet and the surface thoroughly compacted. The tile underdrainings should be placed below this elevation, and should consist of one main line of 6-inch farm tile and 4-inch laterals placed every 4 feet. The main line and laterals should have ample grade, and the earth between the laterals should be sloped 2 inches in 2 feet each way.

Over the tile drains should be placed enough coarse stone, 4 to 6 inches in size, to make the bottom of the filter level. On the top of the coarse stone, finer sizes should be arranged in grades so as to form a bed at the top which will retain the sand. The total depth of the stone should be about 1 foot. The underdrainage must be so arranged that the wastes after passing through the sand will drain freely and quickly away. It is very difficult to inspect the underdrainage after the filter is completed and for this reason strict precautions should be taken at the time of laying in order to prevent trouble from this source later.

Selection of sand.—The sand best suited for treating waste of this character should be of medium size and thoroughly washed free of clay and loam and all other substances that would tend to run together and form a more or less impervious layer. The effective size and uniformity coefficient of the sand used in the tests were 0.23 m. m. and 2.17, respectively, but it is not believed that this particular grade is essential. The main points to consider in selecting the sand are that it should not be too fine, like sea sand, which would not allow the waste to pass through fast enough, or too coarse, which would permit the waste to pass through the bed too quickly.

Placing of sand.—The sand should be carefully placed over the underdrainage so as to prevent its being washed down into the tile and coarse stone. The most practical way of placing the sand is to begin dumping it in one spot and to work it from this point over the bed until 1 or 2 feet are in place.

Application of waste to filters.—Experience with the sand filters at the testing station indicated that the best results can be obtained by the application of small doses to the beds. It has already been suggested in connection with the discussion of the siphons that the wastes be applied to the filters to a depth of one-half inch at each discharge of the siphon. It is realized that with a small amount of wastes more elaborate distributing devices will be necessary than have been used heretofore, in order to get the wastes distributed over the entire area of the sand beds. For this purpose it is recommended that the filters, 20 by 20 feet in plan, be constructed in parallel, giving a total width of 40 feet, arranged in rows or separate units. A main feed line can be laid between the beds and one branch taken off on each side to discharge waste for each 400 square feet of area. This arrangement necessitates a central outfall drain line between the two filters. It is recommended that the main feed lines and branches be made of iron pipe supported on concrete posts set in the ground under the filters. There should be valves on the main lines and branches for regulating the flow, and the branches should end in elbows turned up. Under the elbows there should be placed a platform 2 feet square for the purpose of preventing holes being washed in the sand by the waste coming out of the pipe. The concrete posts supporting the laterals should not be less than 2 feet from the elbows discharging the wastes from the platform.

In tests the effluent from the septic tank was applied to the filters at rates as high as 75,000 gallons per acre per day and satisfactory results obtained. Since, however, it will not be possible for permanent plants to maintain the supervision that was given to the filters in the tests, it is recommended that filters be designed on the basis of 50,000 gallons per acre per day until further data is available on the operation of large plants under the operation of unskilled men.

SLUDGE AND SCUM DISPOSAL.

The septic tanks should be provided with hopper bottoms with a slope of 60 degrees and each hopper provided with a sludge outlet pipe 6 inches in diameter. Each pipe should be provided with a valve so located that it can be protected from frost.

There are probably but few places where the scum and sludge can be dried on filter beds on account of the odors they produce. Since the total quantity produced by any one plant in a year will not be large, it is recommended that scum and sludge be taken direct from the tanks in water-tight containers and discharged into shallow trenches and covered with earth. The scum and sludge have no unusual fertilizing ingredients, and the fat contained in them has no appreciable market value.

If careful attention is given to the details of design and construction given in the preceding paragraphs, it is confidently believed that treatment plants for purifying wastes from the dairy-products industry can be installed that will yield satisfactory results and will not be expensive to operate.

Some intelligent and constant supervision will, however, be required, just as any other apparatus in the creamery requires attention, and unless this consistent and regular attention is given, the treatment plant will fail to yield efficient results for any length of time.

APPENDIX I.

BIBLIOGRAPHY.

1. Mueller, Milch Zeitung, 1887, page 119.
2. Boemer, Zeitschr. f. angew. chemie, 1895, p. 194.
3. Report Massachusetts State Board of Health, 1898.
4. Koenig, Die Verunreinigung des Wässers, 1899, p. 188.
5. Massachusetts State Board of Health, 1899, p. 103.
6. Duclaux. Traité de Microbiologie, Vol. IV, Paris, Masson et Cie., 1901.
7. Opperman, Mölkerei Zeitung, No. 5, 1902.
8. Kattein u. Schoofs, Reinigung von Mölkereiabwassern durch das oxydverfahren, Milch Zeitung, Leipzig, 1903, 32 Jahr., Nos. 7 and 8.
9. Marston, A., Sewage Disposal in Iowa. Iowa Agr. Exp. Sta., Bulletin No. 7, Ames, Iowa, 1903.
10. Experiment Station Record, Department of Agriculture. Waste Waters from Creameries. XVI, p. 194.
11. Massachusetts State Board of Health, 1903, p. 105.
12. Journal Department of Agriculture and Technical Instruction for Ireland, March, 1904. Vol. 4, No. 3.
13. Hoard's Dairyman—1904.
14. Dean, Henry Hoshel, Canadian Dairying. Article on page 135 concerning sewage. 1906. Toronto, W. Briggs, Pub.
15. Lacomble, Revue d'Hygiene, October, 1906, p. 817.
16. Massachusetts State Board of Health, 1906, p. 96.
17. Erf, Prof. Oscar, Disposal of Dairy and Farm Sewage and Water Supply, Kansas State Agricultural College, 1907, Bulletin 143.
18. Kühl, Untersuchungen einer Abwässerschlammes, Zentral. f. Bakter. u. Parasitenk., 11 Abt. 1908, Bd 22, P–1–2.
19. Barbour, F. A., Jour. Eng. Soc. of Pa., vol. 1, 1909, pp. 435–47.
20. Disposal of Wastes from the Dairy Industry. Ohio State Board of Health, Quarterly Bulletin, vol. 1, No. 3, p. 151–170. July–September, 1909.
21. Hederick, "Neue Verfahren zur Reinigung von Abwässern." Zeitsch. f. Gewerbehygiene, Unfallrerhütung, 1909. Jg. 14, S. 272.
22. Disposal of Cheese Factory Wastes. Report of the Ontario Provincial Board of Health for 1909.
23. The Disposal of Cheese Factory Wastes. Report of the Ontario Provincial Board of Health for 1909. Discusses the problems involved and gives descriptions of two plants. 3,300 words. Can. Eng. Nov. 3, 1910.
24. S. C. Thompson, Increasing Creamery Profits by Handling Special Products and Utilizing By-Products. United States Department of Agriculture, Bureau of Animal Industry, Circular 188, 1910.
25. J. König, Neue Erfahrungen über die Behandlung und Beseitigung der Gewerblichen Abwässer, Deutsche Vierteljahr zeitschr. f. öffentl. Ges. Pflege, 1910, Heft 1. S. 111–163.
26. Disposal Butter Factory Wastes, Vol. XXII, p. 581. Experiment Station Record. Department of Agriculture.
27. Universal Portland Cement Co., Chicago, How to Build a Creamery Septic Tank, Valuable Suggestions and Instructions. Creamery Journal, vol. 21, No. 4, p. 16–18. March 15, 1910.

28. H. W. Clark, Disposal and Purification of Manufactural Wastes. Reprint Forty-first Annual Report, Massachusetts State Board of Health, 1910. pp. 47–50.
29. Reinigung von Abwässerdurch Berieselung, Mölkerei Zeitung, Hildeshelm, 24 Jahrg., 1910. Nos. 9 and 10.
30. Recherches sur L'Epuration Des Eaux d'egout, Vol. VI, 1911, p. 75.
31. Disposal of Creamery Wastes. Vol. XXV, p. 82. Experiment Station Record. Department of Agriculture.
32. Bowles, Eng. Rec. 8 vol 64, 1911, p. 419.
33. Guth, F. The Water Supply and the Removal of Waste Water of Creameries. Der Gesundheits-Ingenieur, Munich, Germany, vol. 34, No. 9, pp. 163–165. 1911.
34. Sorenson, James, and Mortensen, M. P. Creamery, Cheese, and Ice Cream Factory Construction. Minnesota Dairy and Food Department, Experimental Creamery Bulletin No. 41. Albert Lea State Creamery, Albert Lea, Minn., Apr., 1912.
35. Industrial Chemistry, Martin, 1913, p. 79.
36. Lindberg, J. E., Minnesota Dairy and Food Department, 1913, Bulletin No. 46.
37. Wisconsin State Board of Health, Purification Plant for Creamery Waste. Madison, Wis., Democratic Printing Co., State Printer, 1913.
38. Report New Jersey State Board of Health, 1914, pp. 242–3.
39. Kershaw, G. B., The Purification of Dairy Wastes. Surveyor, vol. 46, No. 1197, pp. 736–7. 1914.
40. Wilson, A. P., The Disposal of Creamery Refuse, Department Agriculture and Technical Instruction. Ireland Journal, vol. 14, No. 2, pp. 241–251.
41. Ohio Agricultural Commission, Bureau of Dairies, Bulletin No. 3, 1915.
42. Ninth Report, Royal Commission on Sewage Disposal, England, 1915.
43. Disposal of Liquid Wastes from Manufacturing Processes. Reviews Sewage Commissioners' recommendations in ninth report. 12,000 words. Surveyor, April 9, 1915.
44. Farrington, E. H., and Davis, G. J., The Disposal of Creamery Sewage. Wisconsin Agricultural Experiment Station Bulletin No. 245, Madison, Wis., Feb., 1915.
45. New York State Department of Health, Disposal of Creamery Wastes. Vol. 3 of Thirty-sixth Annual Report of New York State Department of Health, 1915.
46. Crohurst, H. R., and Weston, A. D., A Summary of the Results of Experiments on the Purification of Creamery Refuse and Their Application. Engineer and Contract, vol. 44, No. 1, pp. 7–9. 1915.
47. Wilson and H. T. Calvert. Criticism of Sewage Commission's Recommendations. 5,000 words. Surveyor, August 27, 1915.
48. Disposal of Creamery Wastes, Metal Worker, December 10, 1915.
49. Disposal of Wastes from the Dairy Industry, A. E. Kimberly. The Ohio Public Health Journal, July, 1916.
50. Weigle, George J., Sanitary Suggestions. New York Produce Review, vol. 41, No. 24, pp. 950–951, March 29, 1916.
51. Design of Disposal Plant for Creamery or Cheese Factory Wastes. A. E. Kimberly, Engineer and Contractor, September 13, 1916.
52. United States Public Health Service, Treatment and Disposal of Creamery Wastes. December 6, 1918. Reprint No. 496, from Public Health Report, E. B. Phelps.

53. Schindler, L. M., Septic Tank for Cheese Factory Sewage, plan in Hoard's Dairyman, vol. 57, No. 12, p. 596, April 11, 1919.
54. Septic Tank for Cheese Factory and House, Domestic Engineering, vol. 87, pp. 285–6. May 17, 1919.
55. Creamery Wastes, Phelps, E. B. Mun. Jl., Jan. 25, 1919.
56. Schoofs, Les Eaux Residuaires des Laiterie, Revue Generale du Lait, vol. 3, p. 313–4.
57. Michels, Creamery Butter Making.
58. Van Slyke & Publow, The Science and Practice of Cheese Making.
59. Hamilton, Revue Generale du Lait, vol. 4, p. 190.
60. Calmette, Rescherches d'espuration des Eaux d'egout, vol. 6.
61. Marston, Prof. A., Journal Western Society Engineers, vol. 8, No. 6.
62. Opperman, Revue Generale du Lait, vol. 1, p. 501.
63. E. Roth, Zur Frage der Wasser verzorgung und Abwässerbeseitigung in Gewerblichen Betrieben. Viertlj. schr. f. gerichtl. Medizin u öff. Sanitätswesen, 3, Folge, 38, Bd. 2, Heft, pp. 350–383.

APPENDIX II.

DAILY RECORD OF MILK AND CREAM RECEIVED, PRODUCTS MADE, AND WASTE PRODUCED.

Date.	Pounds received.			Fat sold as cream.	Butter made.		Pounds made.			Total waste.	Waste per pound butter fat received.
	Milk.	Cream.	Equivalent in butter fat.		Tubs.	Prints.	Cottage cheese.	Casein.	Condensed milk.		
1916.				*Lbs.*	*Lbs.*	*Lbs.*				*Gals.*	*Gals.*
May 16	4,413	4,044	1,283.4	34.5	1,705		702			3,530	2.7
17	4,294	3,133	1,019.4	74.4	1,494		436	24		2,280	2.2
18	4,506	3,304	1,078.9	15.0	1,157		610			3,780	3.5
19	4,610	2,381	842.1	17.2	658	613	434			4,050	4.8
20	4,896	4,196	1,317.5		2,141	525	767	26		3,120	2.4
22	7,196	4,448	1,492.2	51.0			698	31		4,350	2.9
23	5,868	4,830	1,504.2	33.6	1,130	600	856			3,420	2.3
24	4,943	3,447	1,130.0	99.6		1,701	828			3,100	2.7
25	5,167	3,326	1,115.0	82.0	1,270		715			4,500	4.0
26	4,595	3,325	1,075.2	51.9	896	401	242			4,960	4.6
27	5,613	3,997	1,305.7	67.0	2,696		554			3,770	2.9
28	6,648	4,797	1,581.6	116.6			741			2,320	1.5
Average	5,229	3,769	1,229.0	58.4	1,461	768	632	27		3,598	3.0
Oct. 24					130	1,475			1,413	2,820	
26						1,594		44		3,000	
28	3,053	2,218	771.9	86.6		2,254	534		925	4,040	5.2
30	4,972	3,973	1,256.9	91.2						900	0.72
31	2,817	2,570	799.3	100.7		1,443		51		1,940	2.4
Average	3,614	2,920	943.0	92.8	130	1,292	534	48	1,169	2,540	2.8
Nov. 1						844				1,240	
2	5,102	3,829	1,291.9	35.0					1,200	2,400	1.9
3						1,548				1,000	
4	5,001	3,807	1,285.9	99.5		1,425			875	3,280	2.6
13	4,848	3,715	1,264.4	49.3				122		1,266	1.0
14						1,496	412			3,680	
15	4,732	3,908	1,261.6	68.0				32		2,480	2.0
16						1,471	705			3,100	
18	2,604	2,143	713.7	23.6		2,196			846	3,090	4.3
20	4,882	3,947	1,321.2	61.0						1,860	1.4
21						1,571	620			1,400	
23						1,571				500	
27	5,020	4,042	1,396.1	62.6			325		907	2,860	2.1
28					64	1,562	308			1,940	
29	4,576	3,996	1,323.2	482.5		1,123		39	988	2,800	2.1
Average	4,596	3,673	1,232.0	58.4	64	1,481	475	64	963	2,193	2.2
Dec. 1	4,679	3,063	1,071.3	54.0					820	1,720	1.6
2	3,102	2,117	711.4	34.6		2,060	649		384	3,720	5.2
4	6,269	4,315	1,485.1	71.2			496		1,346	1,800	1.2
5						1,724	252		759	1,420	
6	6,074	4,161	1,427.6	306.2						1,800	1.3
7						1,355				1,380	
8	5,264	3,064	1,117.4	4.0					1,284	2,450	2.2
9	2,756	2,118	730.3	369.9		1,838	444		1,205	2,780	3.8
11	6,775	3,981	1,479.2	271.2					1,437	3,960	2.7
12						1,481	394				
13	7,102	4,274	1,571.7	442.8					464	3,400	2.2
14						1,382	385			1,780	
15	6,249	3,012	1,115.5	408.6			352		946	1,870	1.7
16	2,539	2,305	792.8	394.2		1,357	454		756	2,260	2.9
18	7,431	4,112	1,523.4	414.8					1,309	3,110	2.0
19						1,373	459		435	3,070	
20	7,037	4,228	1,544.6	348.6						2,180	1.4
21						1,448	474		880	2,400	
22	5,495	2,619	989.2	199.7			415		838	2,480	2.5
23	5,494	3,638	1,274.5	883.8		1,390	354		1,159	4,230	3.3
26	9,135	5,803	2,071.5	585.7			270			2,920	1.4
27	7,608	4,139	1,521.8	334.6		1,862	752		674	3,460	2.3
28						1,446	435		1,533	1,320	
29							416		664	1,240	
30	7,340	5,217	1,825.9	1,084.6		904			1,265	4,340	2.4
Average	5,903	3,657	1,309.0	365.2		1,509	438		956	2,549	2.4

Daily record of milk and cream received, products made, and waste produced—Continued.

Date.	Pounds received.			Fat sold as cream.	Butter made.		Pounds made.			Total waste. memm	Waste per pound butter fat received.
	Milk.	Cream.	Equivalent in butter fat.		Tubs.	Prints.	Cottage cheese.	Casein.	Condensed milk.		
1917.				*Lbs.*	*Lbs.*	*Lbs.*				*Gals.*	*Gals.*
Jan. 2	9,884	5,559	2,088.8	607.2	......	......	433	......	1,305	2,980	1.4
3	......	......	......	......	......	1,830	459	......	642	3,020	......
4	7,517	3,975	1,441.8	375.2	......	......	490	......	1,270	2,240	1.6
5	......	......	......	......	400	1,280	488	......	445	2,720	......
6	7,680	4,787	1,742.5	934.8	......	1,008	......	......	1,315	1,740	1.0
8	7,139	3,843	1,423.6	426.8	......	......	424	......	1,263	2,540	1.8
9	......	......	......	......	......	1,226	395	......	353	2,620	......
10	7,940	4,771	1,668.8	568.9	......	......	......	......	1,220	5,230	3.1
11	......	......	......	......	......	1,380	416	......	668	2,500	......
12	6,675	2,741	1,087.0	565.8	......	......	......	......	1,033	1,770	1.6
13	3,748	2,862	958.6	205.0	......	1,595	413	......	614	4,070	4.2
15	8,083	4,683	1,718.0	54.6	......	......	446	......	796	4,780	2.8
16	......	......	......	......	......	2,076	492	......	522	3,420	......
17	8,232	5,026	1,805.0	36.6	......	......	486	......	1,329	4,360	2.4
18	......	......	......	......	1,603	576	406	......	......	1,400	......
19	6,953	3,002	1,190.0	......	......	......	213	......	......	2,300	1.9
20	4,824	3,557	1,210.9	15.0	990	463	451	......	973	4,050	3.3
23	......	......	......	......	501	1,692	786	......	417	1,630	......
24	8,152	5,221	1,872.3	144.0	......	......	......	......	880	3,280	1.8
25	......	......	......	......	559	1,568	419	......	......	1,440	......
26	7,281	3,849	1,313.3	24.2	......	......	407	......	1,201	3,600	2.7
27	4,956	2,825	1,024.9	......	2,811	......	419	......	1,125	5,000	4.9
29	9,288	5,296	1,953.1	36.6	......	......	422	......	1,138	3,400	1.7
30	......	......	......	......	......	2,380	......	......	535	4,620	......
31	9,297	5,555	1,937.8	105.6	......	......	......	......	......	4,750	2.5
Average	7,353	4,222	1,527.0	293.1	1,144	1,423	467	......	907	3,178	2.4
Feb. 1	......	......	......	......	......	2,223	378	......	1,309	3,670	......
2	7,770	2,908	1,149.3	39.6	......	......	406	......	1,169	4,880	4.3
3	4,969	3,014	1,058.7	......	1,757	887	390	......	1,525	4,960	4.7
5	9,000	4,620	1,691.5	45.8	......	......	361	......	658	4,680	2.8
6	......	......	......	......	......	2,013	424	......	928	3,[illegible]40	......
7	10,806	6,027	2,199.2	......	......	......	384	......	724	8,100	3.7
8	......	......	......	......	......	2,762	416	......	1,273	4,930	......
9	9,191	3,179	1,299.6	60.2	......	......	702	......	1,803	3,500	2.7
10	5,218	3,600	1,270.9	41.6	......	2,984	419	......	......	2,140	1.7
12	10,177	5,532	2,021.4	48.0	......	......	......	......	908	3,270	1.6
13	......	......	......	......	......	2,400	748	......	1,115	3,840	......
14	9,666	5,334	1,989.8	......	......	......	407	......	1,042	10,240	5.1
15	......	......	......	......	......	2,463	416	......	1,251	4,000	......
16	8,777	3,252	1,319.8	7.0	......	......	437	......	1,876	3,700	2.8
17	5,351	3,994	1,356.0	51.0	1,037	2,144	392	......	1,641	6,870	5.1
19	10,993	5,500	2,019.1	57.6	......	......	298	......	2,395	5,540	2.7
20	......	......	......	......	995	1,371	401	......	......	6,380	......
21	10,432	5,609	2,024.6	118.2	......	......	391	......	700	4,520	2.2
23	9,223	3,748	1,429.3	52.4	......	......	285	......	1,017	6,810	4.8
24	5,714	3,890	1,330.6	31.0	2,626	534	624	......	1,625	4,130	3.1
28	10,837	6,103	2,154.8	50.0	......	......	375	......	888	4,880	2.3
Average	8,542	4,421	1,621.0	50.2	1,604	1,978	433	......	1,255	4,985	3.3
Mar. 1	......	......	......	......	......	2,538	736	......	914	4,900	......
2	10,262	3,471	1,403.7	56.2	......	......	401	......	1,220	4,330	3.0
3	8,474	4,088	1,497.5	48.6	2,247	1,174	760	......	2,230	4,130	2.8
5	14,151	5,746	2,257.4	69.7	......	......	813	......	1,467	5,420	2.4
6	......	......	......	......	2,628	......	778	......	884	3,460	......
7	14,017	5,467	2,155.7	20.0	......	......	484	......	1,441	6,940	3.2
8	......	......	......	......	2,021	575	793	......	984	4,360	......
9	11,948	3,568	1,508.5	25.0	......	......	435	......	1,792	4,670	3.1
10	8,611	3,971	1,494.7	30.0	3,556	......	796	......	1,851	5,000	3.3
12	14,086	5,983	2,288.0	142.6	......	......	951	......	1,341	6,450	2.8
13	......	......	......	......	1,114	1,542	882	......	896	2,920	......
14	14,041	5,929	2,252.0	71.2	......	......	576	......	1,261	4,780	2.1
15	......	......	......	......	......	2,661	847	......	......	2,540	......
16	11,933	3,514	1,485.0	21.6	1,202	625	603	......	1,803	7,980	5.3
17	8,200	4,461	1,577.3	40.0	1,202	625	925	......	1,821	4,700	3.0
19	14,538	5,796	2,280.8	59.6	......	......	780	......	1,358	4,420	1.9
20	......	......	......	......	......	2,715	1,244	......	......	2,860	......
21	14,503	6,294	2,411.5	71.2	......	......	792	......	1,218	5,440	2.3
22	......	......	......	......	......	2,866	863	......	......	5,560	......
23	12,653	3,473	1,498.5	59.6	1,825	......	725	24	1,821	3,800	2.5
24	8,767	4,216	1,575.2	......	1,826	......	776	......	2,212	5,000	3.2
26	15,841	6,058	2,321.8	100.0	......	......	1,315	......	861	3,860	1.7

Daily record of milk and cream received, products made, and waste produced—Continued.

Date.	Pounds received.			Fat sold as cream.	Butter made.		Pounds made.			Total waste.	Waste per pound butter fat received.
	Milk.	Cream.	Equivalent in butter fat.		Tubs.	Prints.	Cottage cheese.	Casein.	Condensed milk.		
1917.				*Lbs.*	*Lbs.*	*Lbs.*				*Gals.*	*Gals.*
Mar. 27	......	......	......	......	......	2,702	1,180	......	......	4,280	......
28	15,342	5,988	2,390.7	49.7	......	......	1,079	......	1,027	5,380	2.2
29	......	......	......	......	......	2,828	842	......	......	3,960	......
30	12,161	3,373	1,461.3	63.9	1,353	524	1.290	......	......	3,200	2.2
31	9,951	4,667	1,720.2	33.7	1,353	525	1,487	......	......	5,620	3.3
Average	12,193	4,726	1,866.0	56.6	1,848	1,685	898	24	1,420	4,675	2.8
Apr. 2	13,162	6,360	2,319.9	155.1	......	......	1,349	......	883	5,000	3.2
3	......	......	......	......	1,113	1,487	......	......	......	3,260	......
4	15,390	6,616	2,487.5	12.0	......	......	1,247	......	884	5,320	2.1
5	......	......	......	......	2,972	......	1,169	......	......	1,520	......
6	11,983	3,825	1,563.9	46.0	2,000	400	950	......	729	5,240	3.3
7	8,909	4,346	1,611.9	12.9	1,175	221	1,661	......	1,447	2,520	1.6
9	14,974	6,768	2,527.0	79.5	......	......	1,108	......	860	5,640	2 2
10	......	......	......	......	......	2,976	1,151	......	......	3,660	......
11	15,752	6,759	2,538.3	42.9	......	......	1,171	......	1,384	5,840	2.3
12	......	......	......	......	......	3,052	1,232	......	......	1,500	......
13	12,702	4,540	1,723.4	71.7	......	......	1,103	......	892	5,140	3.0
14	10,218	4,650	1,774.1	70.9	1,500	527	1,396	......	1,206	6,000	3.4
16	15,480	7,062	2,662.5	33.2	......	......	1,262	......	961	1,700	0.64
30	17,248	7,643	2,796.9	124.5	1,126	633	776	......	2,094	3,500	1.3
Average	13,582	5,857	2,201.0	64.9	1,651	1,328	1,197	......	1,134	3,989	2.3
May 1	7,887	1,681	767.0	24.9	894	......	887	......	1,342	5,500	7.2
2	11,385	5,992	2,124.0	28.0	1,611	919	866	......	2,883	4,620	2.1
4	11,342	4,843	1,819.5	66.0	1,618	482	......	39	2,804	6,640	3.6
5	10,140	4,037	1,519.7	00.0	1,351	489	487	......	2,739	3,740	2.5
7	16,655	7,581	2,826.1	86.5	2,808	520	708	119	3,132	7,560	2.7
8	9,003	1,502	764.6	48.0	863	......	776	65	3,035	4,840	6.3
9	11.898	6,571	2,269.5	37.9	2,694	......	......	......	2,261	5,690	2.5
10	8,341	1,813	832.8	33.5	973	......	706	......	2,393	5,580	6.7
11	9,961	5,122	1,828.6	71.6	2,128	......	468	......	2,493	4,620	2.5
12	11,549	4,408	1,672.1	43.0	1,990	......	431	......	2,752	3,630	2.2
14	18,722	7,987	2,995.8	46.0	3,007	539	856	......	3,293	5,250	1.8
16	12,998	6,934	2,424.9	66.5	2,835	......	323	......	2,083	9,230	3.8
17	9,419	2,404	1,025.4	62.6	1,162	......	804	42	2,518	8,600	8.4
18	11,795	5,438	1,957.7	69.9	2,277	......	745	......	2,530	6,380	3.3
19	11,983	4,921	1,805.6	12.0	2,161	......	717	......	3,125	7,600	4.2
21	18,964	7,630	2,897.4	183.7	2,196	1,092	800	10	2,310	6,380	2.2
24	10,669	3,198	1,301.0	66.5	1,031	479	380	40	2,509	10,160	7.8
25	12,877	5,618	2,130.9	72.9	2,480	......	108	......	......	5,900	4.8
26	13,085	6,111	2,224.7	25.6	1,536	1,135	......	64	......	9,860	4.4
28	21,078	9,227	3,380.2	147.5	2,141	1,737	811	129	3,854	7,860	2.3
29	14,113	3,765	1,601.4	36.0	1,339	496	730	72	3,075	8,000	5.0
31	12,767	5,485	2,082.4	221.5	2,196	......	958	40	2,191	6,460	3.1
Average	12,574	5,103	1,911.0	65.9	1,877	789	661	62	2,666	6,550	4.0
June 1	13,432	4,721	1,855.9	43.4	2,160	......	787	79	3,042	8,000	4.3
4	20,063	8,341	3,145.9	163.6	3,103	495	1,008	......	3,129	9,800	3.1
6	14,062	6,244	2,217.4	152.8	2,063	461	773	77	2,896	9,900	4.5
8	13,584	5,436	2,008.0	13.0	2,408	......	856	57	3,051	9,500	4.7
11	17,117	7,883	2,808.6	139.7	2,709	471	1,880	77	2,990	8,660	3.1
13	14,252	6,024	2,196.8	139.9	1,524	936	719	30	3,967	10,800	4.9
15	14,109	5,572	2,076.9	24.0	936	1,524	734	55	3,128	8,040	3.9
18	20,567	9,037	3,358.6	23.6	1,660	2,394	1,394	72	3,189	8,770	2.6
19	15,443	5,582	2,100.0	152.3	1,379	1,001	820	81	3,747	11,000	5.2
21	13,994	5,255	1,964.6	42.8	922	1,400	800	......	2,891	11,700	5.8
23	13,879	5,826	2,098.7	60.2	1,952	545	648	128	3,123	10,800	5.1
26	14,719	5,199	2,045.4	67.4	1,977	432	790	......	3,367	10,000	4.9
29	14,737	5,312	1,990.1	58.3	1,352	1,017	823	42	2,389	10,000	5.0
Average	15,381	6,172	2,297.0	83.2	1,857	917	926	70	3,216	9,844	4.4
July 6	12,932	5,305	1,932.7	118.8	1,055	1,181	568	76	3,034	9,300	4.8
7	13,355	5,679	2,041.4	49.6	2,400	......	1,186	......	3,266	11,700	5.7
9	16,324	7,447	2,682.9	139.0	2,130	957	340	79	3,398	9.760	3.6
Average	14,204	6,144	2,219.0	102.5	1,862	1,068	698	77	3,233	10,253	4.7

Appendix III.

DETAILED CHEMICAL AND BACTERIOLOGICAL ANALYSES OF INFLUENT[1] OF SEPTIC TANK.

	Temperature, °F.			Chemical analyses (p. p. m.).														Bacteria (1,000 per c. c.).	
	Influent.	Effluent.	Air.	Suspended solids.	Residue on evaporation.	Turbidity.	Nitrogen as—			Alkalinity.	Acidity.	Chlorides.	Ether soluble matter.	Oxygen consumed: 30 min. 96° C.	Oxygen demand at 20° C.			Agar 30° C., 48 hours.	Endo plates, red colonies.
							Total organic.	Ammoniacal.	Nitrites.						24 hours.	5 days.	10 days.		
1916.																			
May 16–17	74	72	56	286	......	1,750	250	2.0	......	......	64	......	......	2,550	......	......	......	......	......
May 19–20	78	72	49	200	6,334	1,700	180	0.8	......	......	144	......	......	2,220	2,200	......	......	......	......
May 22–23	73	74	57	672	......	1,400	140	1.0	......	......	124	......	......	1,810	......	......	......	......	......
May 25–26	77	78	62	1,048	5,692	2,000	150	1.5	0.016	......	150	......	......	2,220	3,300	......	......	......	......
June 8–9	71	70	62	744	4,920	1,100	200	0.4	.004	120	......	......	......	1,450	950	......	......	......	......
June 13–14	76	73	61	164	5,500	1,000	150	0.2	.012	16	......	......	......	1,480	1,380	......	......	......	......
June 16	73	73	64	208	3,312	450	120	0.8	.010	76	......	......	......	800	930	......	......	......	......
June 27–28	72	72	64	216	2,444	350	56	0.4	......	312	......	......	......	600	680	......	......	......	......
July 1	72	75	66	284	2,216	650	67	0.4	.010	148	......	......	......	675	1,120	......	......	......	......
July 3	74	81	66	192	1,752	350	54	1.6	.005	292	......	......	......	425	880	......	......	......	......
July 6–7	73	73	68	172	2,328	430	100	0.6	......	144	......	......	......	730	1,050	......	......	......	......
July 11–12	80	75	75	106	1,828	340	46	0.2	.006	132	......	......	......	472	370	......	......	......	......
July 14–15	77	79	75	244	2,716	480	......	1.4	.010	236	......	......	......	572	920	......	......	......	......
July 17–18	75	75	71	208	2,932	475	65	1.2	.010	120	......	......	......	640	500	......	......	......	......
July 20–21	77	79	75	546	2,852	425	100	0.3	......	160	......	......	......	705	950	......	......	......	......
July 25–26	77	79	69	622	3,012	1,100	110	0.5	......	176	......	......	......	724	1,600	......	......	......	......
July 28–29	75	79	71	234	2,200	450	64	1.2	.005	416	......	......	......	450	630	......	......	......	......
Aug. 1	77	70	67	350	2,612	700	76	0.4	.005	132	......	......	......	500	1,320	......	......	......	......
Aug. 3–4	80	72	69	348	3,772	500	120	0.2	.100	132	......	......	......	570	880	......	......	......	......
Aug. 8–9	75	72	68	474	2,968	1,200	54	0.4	......	164	......	......	......	585	420	......	......	......	......
Aug. 11–12	76	70	68	472	3,280	1,000	54	0.2	......	72	......	......	......	820	1,100	......	......	......	......
Aug. 14–15	77	74	59	476	3,076	900	100	1.0	......	216	......	......	......	620	530	......	......	......	......
Aug. 17–18	78	78	63	276	2,588	700	62	2.5	......	220	......	......	......	388	450	......	......	......	......
Aug. 22	81	79	70	660	2,500	1,300	48	3.0	.010	232	......	......	......	480	700	......	......	......	......
Aug. 25	77	77	62	804	4,744	1,300	130	1.2	......	184	......	......	......	1,210	1,520	......	......	......	......
Aug. 28	77	72	54	284	2,132	850	37	2.8	.015	212	......	......	......	495	400	......	......	......	......

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[1] Raw waste.

DETAILED CHEMICAL AND BACTERIOLOGICAL ANALYSES OF EFFLUENT OF SEPTIC TANK.

	Net rate on filter G.A.O.	Chemical analyses (p. p. m.).																Bacteria (1,000 per c. c.).	
		Sus-pended solids.	Resi-due on evapo-ration.	Tur-bidity.	Nitrogen as—				Alka-linity.	Acid-ity.	Putres-cibility hours to re-duce M. B. at room tem-pera-ture.	Diss. oxygen.		Oxy-gen con-sumed; 30 min. 96° C.	Oxygen demand at 20° C.				
					Total or-ganic.	Am-mo-niacal.	Ni-trites.	Ni-trates.				P. P. M.	Per cent sat.		24 hours.	5 days.	10 days.	Agar 30° C., 48 hours.	Endo plates, red col-onies.
1916.																			
May 16-17	1,450	104		900	140	22.0	0.020			432				1,600					
May 19-20	1,790	266	2,920	510	78	14.0				684				1,170	1,830				
May 22-23	1,940	214		500	107	13.6				860				940					
May 25-26	2,380	364	2,352	700	100	22.0	.200			560				1,900	3,100				
June 8-9	1,770	344	2,700	900	160	20.0	.020			576				650	1,740				
June 13-14	2,840	152	2,772	940	130	9.2	.035			520				500	1,230				
June 16	2,030	244	2,800	860	100	16.0	.024			496				270	1,120				
June 27-28	1,760	180	1,792	400	70	38.0	.120			272				295	1,220				
July 1	1,385	240	1,720	500	60	12.0	.020			160				290	1,090				
July 3	2,520	280	1,728	365	74	22.0	.004			204				370	1,080				
July 6-7	2,150	360	1,288	380	74	11.0	.010			264				230	860				
July 11-12	2,400	178	1,496	550	36	20.0	.008			180				208	780				
July 14-15	1,800	132	1,552	350	46	50.0	.015			148				164	1,060				
July 17-18	1,900	176	1,676	435	40	32.0	.020			208				190	960				
July 20-21	2,520	236	1,552	470	43	28.0	.015			192				172	1,320				
July 25-26	2,040	352	1,748	1,000	60	40.0				172				236	1,100				
July 28-29	3,120	286	1,680	650	58	18.0								226	760				
Aug. 1	3,480	276	1,420	670	47	19.0				168				212					
Aug. 3-4	1,880	188	1,580	950	50	32.0								176	800				
Aug. 8-9	2,010	304	1,600	1,200	81	15.0				192				172	760				
Aug. 11-12	2,190	452	1,692	1,100	51	25.0				184				239	800				
Aug. 14-15	1,770	280	1,700	1,100	62	10.0				192				236					
Aug. 17-18	1,890	248	1,948	1,000	78	30.0				92				177	680				
Aug. 22	1,290	182	1,532	750		30.0				40				148	640				
Aug. 25	2,160	324	2,172	1,100	36	22.0				152				430					
Aug. 28	1,790	232	2,148	1,300	50	23.0				306				336	460				

DETAILED CHEMICAL AND BACTERIOLOGICAL ANALYSES OF INFLUENT [1] OF SEPTIC TANK.

	Temperature, ° F.			Chemical analyses (p. p. m.)														Bacteria (1,000 per c. c.).	
							Nitrogen as—								Oxygen demand at 20° C.				
	Influent.	Effluent.	Air.	Suspended solids.	Residue on evaporation.	Turbidity.	Total organic.	Ammoniacal.	Nitrites.	Alkalinity.	Acidity.	Chlorides.	Ether soluble matter.	Oxygen consumed: 30 min. 96° C.	24 hours.	5 days.	10 days.	Agar 30° C., 48 hours.	Endo plates, red colonies.
1916–17.																			
Sept. 1	....	....	....	592	4,764	1,600	130	1.5	0.020	112	....	....	....	1,330	520	....	....	....	....
Sept. 5–6	75	75	67	620	2,976	800	80	1.5	....	132	....	....	....	564	780	....	....	....	....
Sept. 7–8	77	76	69	402	2,348	600	51	3.2	....	196	....	....	....	460	630	....	....	....	....
Sept. 11–12	77	72	59	356	2,824	1,300	80	2.0	....	104	....	....	....	640	450	....	....	....	....
Sept. 14–15	74	72	62	800	7,236	1,300	180	10.0	.010	156	....	....	....	1,900	980	....	....	....	....
Sept. 19–20	70	66	38	292	2,856	800	82	1.5	.010	144	....	....	....	560	320	....	....	....	....
Sept. 22–23	72	54	51	704	2,796	1,400	100	1,5	.010	252.	....	....	....	700	660	....	....	....	....
Oct. 25–26	70	65	42	620	2,216	800	65	1.0	.010	248	....	....	....	512	465	....	....	....	....
Oct. 30–31	75	68	38	504	2,128	1,000	50	2.0	.010	204	....	....	....	462	540	....	....	....	....
Nov. 2–3	71	64	34	600	2,084	750	55	.5	.005	220	....	....	....	340	280	....	....	....	....
Nov. 13–14	67	62	32	764	3,892	1,000	120	1.2	.005	52	....	....	....	684	500	....	....	....	....
Nov. 16–17	70	62	25	1,644	8,360	2,000	180	2.0	.010	....	172	....	....	2,020	365	....	....	....	....
Nov. 19–20	70	63	40	472	1,864	....	60	.8	....	68	....	....	....	244	630	....	....	....	....
Nov. 22–23	73	63	36	1,204	4,300	....	180	.2	....	....	300	....	....	884	525	....	....	....	....
Nov. 28–29	72	63	42	316	1,344	....	44	.6	....	120	....	116	....	428	545	....	....	....	....
Dec. 1–2	70	64	30	536	6,544	....	80	1.5	....	20	....	1,800	....	910	835	....	....	....	....
Dec. 3–4	70	68	48	428	2,000	....	57	3.0	....	104	....	170	....	644	415	....	....	....	....
Dec. 6–7	70	68	29	492	4,424	....	80	4.0	....	144	....	1,132	....	850	760	....	....	....	....
Dec. 11–12	68	65	21	336	2,360	....	64	1.0	....	76	....	328	....	710	390	....	....	....	....
Dec. 14–15	67	62	14	168	1,370	....	36	1.0	....	176	....	76	....	602	200	....	....	....	....
Dec. 22–23	71	63	24	1,448	3,834	....	210	.5	....	....	132	184	....	964	1,260	....	....	....	....
Dec. 25–26	64	61	22	628	1,416	....	64	1.5	....	72	....	126	....	338	415	....	....	....	....
Jan. 2–3	70	65	35	860	3,918	....	150	.5	.050	....	92	1,104	....	790	800	....	....	....	....
Jan. 5–6	73	66	44	104	1,388	....	64	.3	....	80	....	212	....	224	570	....	....	....	....
Jan. 8–9	69	66	34	744	3,220	....	92	.6	.050	....	68	784	....	640	700	....	....	....	....
Jan. 11–12	70	63	8	334	1,520	....	80	.8	.025	368	....	....	....	440	310	....	....	....	....
Jan. 16–17	69	67	6	464	905	....	50	.3	.025	168	....	60	173	131	330	....	....	....	....
Jan. 19–20	71	64	25	340	1,732	....	62	2.5	.010	....	20	77	38	536	690	....	....	....	....
Jan. 24–25	67	68	18	1,120	5,032	....	170	.8	.015	....	276	....	82	1,284	1,000	....	....	....	....

[1] Raw waste.

DETAILED CHEMICAL AND BACTERIOLOGICAL ANAYLSES OF EFFLUENT OF SEPTIC TANK.

	Net rate on filter G.A.D.	Chemical analyses (p. p. m.).																Bacteria (1,000 per c. c.).	
		Sus-pended solids.	Resi-due on evapo-ration.	Tur-bidity.	Nitrogen as—				Alka-linity.	Acid-ity.	Putres-cibility hours to re-duce M. B. at room tem-pera-ture.	Diss. oxygen.		Oxy-gen con-sumed; 30 min. 96° C.	Oxygen demand at 20° C.				
					Total or-ganic.	Am-mo-niacal.	Ni-trites.	Ni-trates.				P. P. M.	Per cent sat.		24 hours.	5 days.	10 days.	Agar 30° C., 48 hours.	Endo plates, red col-onies.
1916-17.																			
Sept. 1	....	268	1,980	1,100	66	14.0	....	....	....	304	....	....	....	332	830	....	....	....	....
Sept. 5-6	1,740	320	1,976	1,100	....	41.0	0.010	....	....	240	....	....	....	174	870	....	....	....	....
Sept. 7-8	1,540	176	1,364	800	40	33.0	.020	....	....	100	....	....	....	177	610	....	....	....	....
Sept. 11-12	1,340	228	2,037	1,200	50	23.0	.010	....	....	144	....	....	....	282	470	....	....	....	....
Sept. 14-15	1,730	768	3,808	1,200	120	35.0	.020	....	....	496	....	....	....	840	550	....	....	....	....
Sept. 19-20	1,660	258	1,929	1,100	63	17.0	.020	....	....	256	....	....	....	224	300	....	....	....	....
Sept. 22-23	1,880	284	1,616	1,000	68	28.0	.020	....	....	136	....	....	....	175	570	....	....	....	....
Oct. 25-26	1,230	352	1,896	800	42	18.0	.010	....	....	20	....	....	....	240	560	....	....	....	....
Oct. 30-31	1,660	204	1,360	800	28	36.0	.005	....	....	60	....	....	....	124	570	....	....	....	....
Nov. 2-3	1,080	296	1,616	800	37	17.0	.005	....	32	....	....	....	....	149	670	....	....	....	....
Nov. 13-14	1,240	164	1,288	650	34	36.0	.005	....	....	224	....	....	....	161	580	....	....	....	....
Nov. 16-17	880	320	2,400	800	70	15.0	.010	....	....	452	....	....	....	320	470	....	....	....	....
Nov. 19-20	930	304	1,444	....	52	14.0	....	....	....	76	....	....	....	142	555	....	....	....	....
Nov. 22-23	550	232	1,296	....	48	22.0	....	....	....	308	....	....	....	149	940	....	....	....	....
Nov. 28-29	1,180	312	1,524	....	36	14.0	.005	....	....	160	....	....	....	287	535	....	....	....	....
Dec. 1-2	910	408	1,924	....	58	22.0	....	....	....	216	....	....	....	437	775	....	....	....	....
Dec. 3-4	1,360	372	2,044	....	51	35.0	....	....	....	496	....	....	....	386	710	....	....	....	....
Dec. 6-7	900	324	1,756	....	42	38.0	....	....	....	104	....	....	....	202	660	....	....	....	....
Dec. 11-12	800	220	1,044	....	34	16.0	....	....	....	24	....	....	....	184	330	....	....	....	....
Dec. 14-15	1,430	128	1,321	....	26	18.0	.005	....	....	40	....	....	....	63	145	....	....	....	....
Dec. 22-23	910	265	1,156	....	18	18.0	.005	....	....	48	....	....	....	72	425	....	....	....	....
Dec. 25-26	1,680	556	1,304	....	55	21.0	....	....	....	72	....	....	....	169	410	....	....	....	....
Jan. 2-3	1,460	368	1,372	....	65	5.0	.010	....	....	132	....	....	....	240	475	....	....	....	....
Jan. 5-6	1,500	324	1,720	....	56	14.0	.010	....	....	61	....	....	....	168	620	....	....	....	....
Jan. 8-9	1,110	272	1,276	....	28	16.0	.050	....	....	80	....	....	....	169	510	....	....	....	....
Jan. 11-12	1,290	328	1,220	....	63	7.0	.010	....	28	....	....	....	....	195	350	....	....	....	....
Jan. 16-17	1,360	292	1,039	....	75	9.0	.015	....	....	106	31	....	....	222	660	....	....	....	....
Jan. 19-20	1,580	232	1,116	....	50	17.0	.005	....	....	172	77	....	....	241	680	....	....	....	....
Jan. 24-25	1,180	328	1,756	....	37	17.0	.025	....	....	292	10	....	....	272	910	....	....	....	....

DETAILED CHEMICAL AND BACTERIOLOGICAL ANALYSES OF INFLUENT[1] OF SEPTIC TANK.

	Temperature, ° F.			Chemical analyses (p. p. m.)														Bacteria (1,000 per c. c.).	
							Nitrogen as—								Oxygen demand at 20° C.				
	Influent.	Effluent.	Air.	Suspended solids.	Residue on evaporation.	Turbidity.	Total organic.	Ammoniacal.	Nitrites.	Alkalinity.	Acidity.	Chlorides.	Ether soluble matter.	Oxygen consumed: 30 min. 96° C.	24 hours.	5 days.	10 days.	Agar 30° C., 48 hours.	Endo plates, red colonies.
1917.																			
Feb. 1-2	70	63	4	716	2,128	....	50	2.0	.010	96	....	....	340	550	723	....	....	....	....
Feb. 9-10	67	63	5	504	1,916	....	55	1.5	.025	124	....	....	287	506	576	....	....	....	....
Feb. 14-15	69	63	17	764	4,440	....	180	.5	.015	52	....	....	71	1,256	790	....	....	....	....
Feb. 19-20	69	66	34	420	2,861	....	140	.4	.005	8	....	....	45	898	643	....	....	....	....
Mar. 5-6	68	65	12	588	4,342	....	200	.5	.010	24	....	....	55	1,236	390	....	....	....	....
Mar. 13-14	70	68	35	1,916	4,080	....	89	1.2	....	....	40	....	925	988	1,480	....	....	....	....
Mar. 20-21	73	66	39	1,088	7,304	....	140	2.0	....	....	400	....	54	2,050	900	....	....	....	....
Mar. 29-30	72	68	37	864	2,981	....	63	1.2	.015	192	....	....	237	866	....	....	....	....	....
Apr. 6-7	67	65	32	1,308	3,408	....	96	.2	....	....	32	....	700	1,050	1,008	1,520	....	....	....
Apr. 8-9	63	64	28	524	1,432	....	60	4.0	....	68	....	....	152	464	243	1,020	....	....	....
May 8-9	74	68	45	768	2,444	....	67	1.2	.025	20	....	....	278	890	710	....	....	....	....
May 13-14	66	48	50	568	....	....	54	.5	....	204	....	....	231	588	240	1,210	....	....	....
May 24-25	74	71	48	512	....	....	100	.6	.005	104	....	....	....	1,042	....	....	....	....	....
May 30-31	82	63	68	252	....	....	44	.3	....	48	....	....	....	528	260	740	1,130	....	....
June 6-7	80	76	66	444	....	....	70	.5	....	....	28	....	....	644	748	1,865	....	....	....
June 11-12	81	76	64	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
June 14-15	73	65	59	760	....	....	55	.6	.075	180	....	....	....	640	555	....	....	....	....
June 22-23	76	75	74	368	....	....	56	.8	....	20	....	....	....	560	650	1,180	....	....	....
June 24-25	81	75	64	552	....	....	67	1.2	....	....	112	....	....	668	736	....	....	....	....
July 11-12	75	70	64	580	....	....	50	.5	....	....	88	....	....	1,260	575	....	2,450	....	....
July 22-23	77	77	74	390	....	....	32	1.0	....	....	268	....	....	580	639	667	1,192	....	....
July 25-26	78	76	78	260	....	....	48	.1	....	160	....	....	....	764	468	1,250	1,317	....	....
July 30-31	77	77	80	292	....	....	45	1.4	....	....	104	....	....	660	590	1,392	....	....	....

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[1] Raw waste.

DETAILED CHEMICAL AND BACTERIOLOGICAL ANALYSES OF EFFLUENT OF SEPTIC TANK.

	Net rate on filter G.A.D.	Chemical analyses (p. p. m.).																Bacteria (1,000 per c. c.).	
		Suspended solids.	Residue on evaporation.	Turbidity.	Nitrogen as—				Alkalinity.	Acidity.	Putrescibility hours to reduce M. B. at room temperature.	Diss. oxygen.		Oxygen consumed; 30 min. 96° C.	Oxygen demand at 20° C.			Agar 30° C., 48 hours.	Endo plates, red colonies.
					Total organic.	Ammoniacal.	Nitrites.	Nitrates.				P. P. M.	Per cent sat.		24 hours.	5 days.	10 days.		
1917.																			
Feb. 1-2	2,140	368	1,652		35	11.0	0.015				160			257	648				
Feb. 9-10	1,910	172	956		33	11.0	0.050		44		81			151	444				
Feb. 14-15	3,560	380	1,588		58	6.0				96	53			358	545				
Feb. 19-20	2,980	236	1,160		52	12.0				180	33			264	610				
Mar. 5-6	2,260	428	1,448		67	5.0	0.015			140	32			323	410				
Mar. 13-14	1,920	408	1,729		27	18.0				8	115			154	580				
Mar. 20-21	2,080	568	1,428		45	4.5				216	68			308	818				
Mar. 29-30	1,790	656	1,992		66	7.5	0.025			200	91			315					
Apr. 6-7	940	520	1,348		40	1.6			24		214			195	390	913			
Apr. 8-9	2,820	612	1,720		50	10.0				40	203			285	345				
May 8-9	2,630	280	1,232		42	6.0	0.015			288	18			338	733	1,200			
May 13-14	2,620	342			36	16.0				188	42			276	478	1,645			
May 24-25	4,280	220			32	3.6				180				231					
May 30-31	3,630	160			26	20.0				80				184	580	1,153	1,533		
June 6-7	4,020	356			56	8.0				156				280	503	1,067	1,400		
June 11-12	5,000	136			20		0.010			356				132					
June 11-15	4,360	404			44	5.6				108				236	625				
June 22-23	4,810	224			42	16.0				140				230	678	1,053			
June 24-25	3,040	304			49	7.2				292				339	666				
July 11-12		240			34	17.0				348				238	750		2,300		
July 22-23		200			36	10.0				346				177	900	1,575			
July 25-26		200			28	2.0				360				220	587	1,489			
July 30-31		236			40	3.4				450				224	652	1,419			

DETAILED CHEMICAL AND BACTERIOLOGICAL ANALYSES OF INFLUENT[1] OF SEPTIC TANK.

	Temperature, ° F.			Chemical analyses (p. p. m.)														Bacteria (1,000 per c. c.).	
							Nitrogen as—								Oxygen demand at 20° C.				
	Influent.	Effluent.	Air.	Suspended solids.	Residue on evaporation.	Turbidity.	Total organic.	Ammoniacal.	Nitrites.	Alkalinity.	Acidity.	Chlorides.	Ether soluble matter.	Oxygen consumed: 30 min. 96° C.	24 hours.	5 days.	10 days.	Agar 30° C., 48 hours.	Endo plates, red colonies.
1917.																			
Aug 2-3	73	73	76	850	....	....	54	0.8	....	....	126	....	....	1,480	750	2,200	2,300	....	....
Aug. 7-8	80	78	74	436	....	....	37	1.0	....	....	148	....	....	460	472	1,172	1,133	....	....
Aug. 10-11	75	75	61	540	....	....	27	.7	....	....	216	....	....	484	530	1,690	....	....	....
Aug. 12-13	77	76	70	336	....	....	60	2.3	....	....	176	....	....	414	....	....	....	....	....
Aug. 15-16	74	76	68	148	....	....	34	1.9	....	....	64	....	....	332	426	570	958	....	....
Aug. 20-21	78	77	70	156	....	....	21	5.0	....	....	22	....	....	130	310	425	866	....	....
Aug. 23-24	78	74	70	340	....	....	22	.5	....	300	....	....	....	176	290	733	1,068	....	....
Aug. 28-29	72	72	68	392	....	....	16	1.6	....	....	120	....	....	272	335	1,010	900	1,300	320
Sept. 1	75	72	70	182	....	....	185	13.0	....	....	830	....	....	2,700	1,560	3,550	5,100	....	....
Sept. 2-3	74	72	66	60	....	....	40	....	....	....	72	....	....	320	....	....	....	....	....
Sept. 6-7	77	72	54	598	....	....	76	3.8	....	....	172	....	....	779	585	1,716	2,340	....	....
Sept. 10-11	71	70	49	196	....	....	48	2.0	....	96	....	....	....	512	45	1,466	....	780	120
Sept. 13-14	75	72	50	960	....	....	49	1.0	....	....	140	....	....	480	445	1,400	1,925	1,500	310
Sept. 18-19	73	73	55	280	....	....	59	1.4	....	350	....	....	....	487	290	975	1,390	6,200	1,200
Sept. 21-22	72	73	56	140	....	....	28	1.3	....	....	44	....	....	86	85	340	560	3,600	1,200
Sept. 26-27	76	72	48	460	....	....	47	1.1	....	....	60	....	....	360	445	890	1,140	2,500	280
Oct. 1-2	76	71	42	384	....	....	68	4.0	....	....	260	....	....	744	400	1,583	2,025	6,700	....
Oct. 4-5	76	73	52	204	....	....	38	2.0	....	....	84	....	....	428	65	1,500	2,117	2,900	760
Oct. 9-10	74	70	37	....	....	....	76	4.0	....	....	132	....	....	762	125	1,175	1,975	1,500	580
Oct. 14-15	73	64	53	364	....	....	72	8.0	....	....	100	....	....	516	495	1,525	2,305	....	....
Oct. 17-18	73	69	48	444	....	....	85	3.4	....	....	410	....	....	898	640	1,866	2,100	....	....
Oct. 22-23	66	59	36	532	....	....	90	9.6	....	....	124	....	....	944	1,055	2,950	....	3,200	660

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[1] Raw waste.

DETAILED CHEMICAL AND BACTERIOLOGICAL ANALYSES OF EFFLUENT OF SEPTIC TANK.

	Net rate on filter G.A.D.	Chemical analyses (p. p. m.).																Bacteria (1,000 per c. c.).	
		Suspended solids.	Residue on evaporation.	Turbidity.	Nitrogen as—				Alkalinity.	Acidity.	Putrescibility hours to reduce M. B. at room temperature.	Diss. oxygen.		Oxygen consumed; 30 min. 96° C.	Oxygen demand at 20° C.				
					Total organic.	Ammoniacal.	Nitrites.	Nitrates.				P. P. M.	Per cent sat.		24 hours.	5 days.	10 days.	Agar 30° C., 48 hours.	Endo plates, red colonies.
1917.																			
Aug. 2-3	......	176	......	......	16.0	2.4	......	......	......	188	......	......	......	189	417	770	1,050	......	......
Aug. 7-8	......	228	......	......	15.0	5.4	......	......	......	220	......	......	......	184	512	918	......	......	......
Aug. 10-11	......	292	......	......	28.0	2.5	......	......	......	224	......	......	......	173	575	1,012	1,258	......	......
Aug. 12-13	......	212	......	......	44.0	7.0	......	......	......	288	......	......	......	170	......	......	......	......	......
Aug. 15-16	......	220	......	......	40.0	7.4	......	......	......	100	......	......	......	118	410	595	1,000	......	......
Aug. 20-21	......	152	......	......	34.0	10.0	......	......	......	50	......	......	......	116	603	866	1,125	......	......
Aug. 23-24	......	174	......	......	27.0	0.8	......	......	......	80	......	......	......	95	280	675	1,058	1,500	201
Aug. 28-29	......	260	......	......	13.0	2.6	......	......	......	128	......	......	......	180	480	995	......	......	......
Sept. 1	......	72	......	......	19.0	9.0	......	......	......	144	......	......	......	95	530	866	1,408	......	......
Sept. 2-3	......	488	......	......	22.0	5.8	......	......	......	324	......	......	......	154	......	......	......	......	......
Sept. 6-7	......	272	......	......	41.0	9.5	......	......	......	480	......	......	......	216	430	1,775	2,435	......	......
Sept. 11-10	......	200	......	......	21.0	2.8	......	......	......	160	......	......	......	207	20	500	600	20,900	18,200
Sept. 13-14	......	356	......	......	49.0	1.0	......	......	......	140	......	......	......	281	487	1,000	1,291	42,000	......
Sept. 18-19	......	272	......	......	56.0	4.0	......	......	......	100	......	......	......	363	40	1,008	1,141	14,200	11,700
Sept. 21-22	......	148	......	......	42.0	2.0	......	......	......	72	......	......	......	159	30	775	1,266	......	......
Sept. 26-27	......	56	......	......	44.0	4.4	......	......	......	160	......	......	......	187	335	350	891	18,000	17,300
Oct. 1-2	......	240	......	......	36.0	8.0	......	......	......	228	......	......	......	177	45	750	1,283	34,000	24,000
Oct. 4-5	......	120	......	......	57.0	2.8	......	......	......	496	......	......	......	282	10	1,667	2,350	6,200	......
Oct. 9-10	......	......	......	......	63.0	5.0	......	......	......	324	......	......	......	256	140	991	1,666	1,520	390
Oct. 14-15	......	140	......	......	61.0	11.0	......	......	......	428	......	......	......	214	312	1,950	2,075	......	......
Oct. 17-18	......	236	......	......	48.0	8.0	......	......	......	348	......	......	......	178	405	733	1,525	......	......
Oct. 22-23	......	176	......	......	68.0	12.0	......	......	......	112	......	......	......	223	220	650	700	1,500	180

APPENDIX IV.

DETAILED CHEMICAL AND BACTERIOLOGICAL ANALYSES OF INFLUENT[1] TO SAND FILTER NO. 1.

	Temperature, ° F.			Chemical analyses (p. p. m.).														Bacteria (1,000 per c. c.).	
							Nitrogen as—								Oxygen demand at 20° C.				
	Influent.	Effluent.	Air.	Suspended solids.	Residue on evaporation.	Turbidity.	Total organic.	Ammoniacal.	Nitrites.	Alkalinity.	Acidity.	Chlorides.	Ether soluble matter.	Oxygen consumed: 30 min. 96° C.	24 hours.	5 days.	10 days.	Agar 30° C., 48 hours.	Endo plates, red colonies.
1916.																			
May 19-20	72	53	49	266	2,920	510	78	14.0	0.000	....	684	....	....	1,170	1,830	....	....	....	....
May 22-23	74	57	57	214	....	500	110	13.0	0.000	....	860	....	....	940	....	....	....	....	....
May 25-26	79	64	62	364	2,352	700	100	22.0	0.200	....	560	....	....	1,900	3,100	....	....	....	....
July 28-29	78	72	71	286	1,680	650	58	18.0	0.000	....	....	....	....	226	760	....	....	....	....
Aug. 1	75	71	66	276	1,420	670	47	19.0	0.000	....	168	....	....	212	....	....	....	....	....
Aug. 3-4	79	72	69	188	1,580	950	50	32.0	0.000	....	....	....	....	176	800	....	....	....	....
Aug. 8-9	76	72	64	304	1,600	1,200	81	15.0	0.000	....	192	....	....	172	760	....	....	....	....
Aug. 11-12	77	70	68	452	1,692	1,100	51	25.0	0.000	....	184	....	....	239	800	....	....	....	....
Aug. 14-15	74	64	59	280	1,700	1,100	62	10.0	0.000	....	192	....	....	236	610	....	....	....	....
Aug. 17-18	78	67	63	248	1,948	1,000	78	30.0	0.000	....	92	....	....	177	680	....	....	....	....
Aug. 21-22	80	73	71	1,182	1,532	750	....	30.0	0.000	....	40	....	....	148	640	....	....	....	....
Aug. 24-25	77	68	58	324	2,172	1,100	36	22.0	0.000	....	152	....	....	430	820	....	....	....	....
Aug. 27-28	72	63	54	232	2,148	1,300	50	23.0	0.000	....	306	....	....	336	460	....	....	....	....
Aug. 30-31	75	62	56	268	1,980	1,100	66	14.0	0.000	....	304	....	....	332	833	....	....	....	....
Sept. 5-6	75	65	67	320	1,976	1,100	....	41.0	0.010	....	240	....	....	174	815	....	....	....	....
Sept. 7-8	76	68	69	176	1,364	800	40	33.0	0.020	....	100	....	....	177	610	....	....	....	....
Sept. 11-12	72	63	59	228	2,036	1,200	50	23.0	0.010	....	144	....	....	282	473	....	....	....	....
Sept. 14-15	72	63	62	768	3,808	1,200	125	35.0	0.020	....	496	....	....	840	553	....	....	....	....
Sept. 19-20	66	52	42	258	1,929	1,100	63	17.0	0.020	....	256	....	....	224	300	....	....	....	....
Sept. 22-23	69	54	55	284	1,616	1,000	68	28.0	0.020	....	136	....	....	175	573	....	....	....	....
Oct. 25-26	65	44	42	352	1,896	800	42	18.0	0.010	....	20	....	....	240	560	....	....	....	....
Oct. 30-31	68	48	38	204	1,360	800	28	36.0	0.005	....	60	....	....	124	395	....	....	....	....
Nov. 2-3	64	46	42	296	1,616	800	37	17.0	0.005	....	....	....	....	149	670	....	....	....	....
Nov. 22-23	63	39	27	232	1,296	....	48	22.0	0.000	....	308	....	....	149	940	....	....	....	....
Nov. 28-29	63	40	47	312	1,524	....	36	14.0	0.005	....	160	280	....	287	535	....	....	....	....

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[1] Effluent from septic tank.

DETAILED CHEMICAL AND BACTERIOLOGICAL ANALYSES OF EFFLUENT OF SAND FILTER NO. 1.

	Net rate on filter G.A.O.	Chemical analyses (p. p. m.).																Bacteria (1,000 per c. c.).	
		Sus-pended solids.	Resi-due on evapo-ration.	Tur-bidity.	Nitrogen as—				Alka-linity.	Acid-ity.	Putres-cibility hours to re-duce M. B. at room tem-pera-ture.	Diss. oxygen.		Oxy-gen con-sumed: 30 min. 96° C.	Oxygen demand at 20° C.				
					Total or-ganic.	Am-mo-niacal.	Ni-trites.	Ni-trates.				P. P. M.	Per cent sat.		24 hours.	5 days.	10 days.	Agar 30° C., 48 hours.	Endo plates, red col-onies.
1916.																			
May 19-20	23,000	18	1,120	25	5.00	55.00	13.00	42.0	252	....	+144	....	....	65.0	....	....	....	....	....
May 22-23	26,400	12	....	25	4.00	64.00	15.00	48.0	132	....	+144	....	....	86.0	....	....	....	....	....
May 25-26	23,500	1	2,320	10	12.00	28.00	13.00	120.0	172	....	+144	....	....	41.0	....	....	....	....	....
July 28-29	27,200	7	3,292	10	0.44	0.16	0.85	2.0	208	....	+144	....	....	17.0	....	....	....	....	....
Aug. 1	27,800	11	2,168	7	0.16	0.04	0.30	120.0	292	....	+144	....	....	12.0	2.4	....	....	....	....
Aug. 3-4	27,400	4	2,200	7	0.12	0.20	0.30	86.0	284	....	+144	....	....	10.0	8.0	....	....	....	....
Aug. 8-9	26,000	3	1,740	3	0.50	0.10	0.35	84.0	292	....	+144	5.0	56	8.6	1.7	....	....	....	....
Aug. 11-12	27,100	14	1,204	15	1.00	0.08	1.50	30.0	384	....	49	5.2	60	8.8	8.4	....	....	....	....
Aug. 14-15	28,500	12	1,340	5	0.50	0.10	0.21	45.0	312	....	+144	5.0	52	5.2	1.8	....	....	....	....
Aug. 17-18	26,600	4	1,382	5	0.92	0.08	0.25	22.0	420	....	+144	5.0	54	6.0	2.0	....	....	....	....
Aug. 21-22	28,200	3	2,500	8	0.04	0.08	0.12	30.0	300	....	+144	6.0	69	7.4	1.6	....	....	....	....
Aug. 24-25	26,600	7	1,212	5	0.16	0.08	0.05	14.0	348	....	+144	6.4	71	5.0	1.1	....	....	....	....
Aug. 27-28	29,800	3	1,368	5	0.20	0.06	0.14	16.0	424	....	+144	5.8	61	10.0	2.4	....	....	....	....
Aug. 30-31	27,000	2	....	5	0.28	0.06	0.12	9.2	492	....	+144	5.0	52	6.8	10.0	....	....	....	....
Sept. 5-6	30,400	7	1,396	10	0.14	0.06	0.17	9.2	460	....	+144	4.5	48	4.8	2.3	....	....	....	....
Sept. 7-8	30,800	9	1,228	7	0.68	0.04	0.40	20.0	432	....	+144	5.1	56	4.2	0.9	....	....	....	....
Sept. 11-12	28,400	3	1,600	5	0.48	0.04	0.40	32.0	360	....	+144	5.8	59	6.4	6.1	....	....	....	....
Sept. 14-15	26,800	3	1,432	8	0.28	0.04	0.56	23.0	408	....	+144	6.7	67	5.4	1.2	....	....	....	....
Sept. 19-20	29,800	6	1,272	7	1.60	0.04	0.56	10.0	492	....	+144	6.2	62	5.7	15.0	....	....	....	....
Sept. 22-23	28,600	....	1,160	3	0.10	0.10	0.08	10.0	484	....	+144	5.6	52	1.4	....	....	....	....	....
Oct. 25-26	41,800	1	1,264	8	0.40	0.04	0.05	22.0	356	....	+144	10.0	90	6.2	3.0	....	....	....	....
Oct. 30-31	40,200	10	1,324	10	0.44	0.04	0.02	13.0	364	....	+144	9.4	81	6.0	1.4	....	....	....	....
Nov. 2-3	47,400	2	1,328	3	0.44	0.04	0.02	4.0	404	....	+144	5.6	48	3.8	13.0	....	....	....	....
Nov. 22-23	62,900	11	1,068	....	0.86	0.10	0.06	9.0	412	....	+144	....	....	5.2	....	....	....	....	....
Nov. 28-29	62,600	2	704	....	0.50	0.10	0.04	2.8	432	....	+144	5.2	40	7.8	....	....	....	....	....

DETAILED CHEMICAL AND BACTERIOLOGICAL ANALYSES OF INFLUENT[1] TO SAND FILTER NO. 1.

	Temperature, ° F.			Chemical analyses (p. p.m.).														Bacteria (1,000 per c. c.).	
							Nitrogen as—								Oxygen demand at 20° C.				
	Influent.	Effluent.	Air.	Suspended solids.	Residue on evaporation.	Turbidity.	Total organic.	Ammoniacal.	Nitrites.	Alkalinity.	Acidity.	Chlorides.	Ether soluble matter.	Oxygen consumed: 30 min. 96° C.	24 hours.	5 days.	10 days.	Agar 30° C., 48 hours.	Endo plates, red colonies.
1916–17.																			
Dec. 1–2	64	45	30	408	1,924	....	58	22.0	0.000	....	216	224	....	437	775	....	....	....	....
Dec. 3–4	68	46	48	372	2,044	....	51	35.0	0.000	....	496	408	....	386	710	....	....	....	....
Dec. 6–7	68	47	29	324	1,756	....	42	38.0	0.000	....	104	392	....	202	660	....	....	....	....
Dec. 11–12	65	49	61	220	1,044	....	34	16.0	0.000	....	24	182	....	184	330	....	....	....	....
Dec. 14–15	62	43	14	128	1,324	....	26	18.0	0.005	....	40	326	....	63	145	....	....	....	....
Dec. 22–23	63	39	24	265	1,156	....	18	18.0	0.005	....	48	446	....	72	425	....	....	....	....
Jan. 2–3	65	39	35	368	1,372	....	65	5.0	0.010	....	132	416	....	240	475	....	....	....	....
Jan. 5–6	66	38	41	324	1,720	....	56	14.0	0.010	....	64	418	....	168	620	....	....	....	....
Jan. 8–9	66	41	34	272	1,276	....	28	16.0	0.050	....	80	232	....	169	510	....	....	....	....
Jan. 11–12	63	38	9	328	1,220	....	63	7.0	0.010	....	....	....	....	195	350	....	....	....	....
Jan. 16–17	67	37	6	292	1,039	....	75	9.0	0.015	....	106	124	34	222	660	....	....	....	....
Jan. 19–20	64	36	25	232	1,116	....	50	17.0	0.005	....	172	90	77	241	680	....	....	....	....
Jan. 29–30	65	39	38													....	....	....	....
Feb. 1–2	63	38	18	368	1,652	....	35	11.0	0.015	....	....	....	160	257	648	....	....	....	....
Feb. 6–7	63	36	18													....	....	....	....
Feb. 9–10	63	34	5	172	956	....	33	11.0	0.050	....	....	....	81	151	....	....	....	....	....
Feb. 14–15	63	36	17	380	1,588	....	58	6.0	0.000	....	96	....	53	358	....	....	....	....	....
Feb. 19–20	66	36	34	236	1,160	....	52	12.0	0.000	....	180	....	33	264	....	....	....	....	....
Feb. 22–23	66	36	38													....	....	....	....
Mar. 5–6	65	36	12	428	1,448	....	67	5.0	0.015	....	140	....	32	323	410	....	....	....	....
Mar. 8–9	66	37	35													....	....	....	....
Mar. 13–14	68	38	35	408	1,720	....	27	18.0	0.000	....	8	....	115	154	580	....	....	....	....
Mar. 16–17	66	40	38	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Mar. 18–19	63	37	18													....	....	....	....
Mar. 20–21	66	41	39	568	1,428	....	45	4.5	0.000	....	216	....	68	308	....	....	....	....	....
Mar. 26–27	68	45	51													....	....	....	....
Mar. 29–30	68	43	37	656	1,992	....	66	7.5	0.025	....	200	....	91	315	....	....	....	....	....

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[1] Effluent from septic tank.

DETAILED CHEMICAL AND BACTERIOLOGICAL ANALYSES OF EFFLUENT OF SAND FILTER NO. 1.

	Net rate on filter G.A.O.	Chemical analyses (p. p. m.).																Bacteria (1,000 per c. c.).	
		Suspended solids.	Residue on evaporation.	Turbidity.	Nitrogen as—				Alkalinity.	Acidity.	Putrescibility hours to reduce M. B. at room temperature.	Diss. oxygen.		Oxygen consumed: 30 min. 96° C.	Oxygen demand at 20° C.				
					Total organic.	Ammoniacal.	Nitrites.	Nitrates.				P. P. M.	Per cent sat.		24 hours.	5 days.	10 days.	Agar 30° C., 48 hours.	Endo plates, red colonies.
1916–17.																			
Dec. 1–2	47,000	5	848	....	0.74	0.06	0.10	7.0	400	....	120	11.6	91	6.0	3.2	....	....	....	....
Dec. 3–4	52,800	5	852	....	0.56	0.04	0.03	7.2	452	....	144+	9.2	75	8.4	1.1	....	....	....	....
Dec. 6–7	55,900	15	1,040	....	2.00	0.04	0.15	4.8	444	....	100	8.0	69	6.6	11.0	....	....	....	....
Dec. 11–12	58,000	1	1,004	....	0.52	0.12	0.06	9.6	304	....	144+	9.8	88	6.6	0.5	....	....	....	....
Dec. 14–15	54,200	....	1,036	....	0.48	0.16	0.12	24.0	232	....	144+	....	....	6.4	0.0	....	....	....	....
Dec. 22–23	51,100	5	848	....	2.40	0.16	0.06	9.6	288	....	144+	10.9	84	5.8	2.0	....	....	....	....
Jan. 2–3	80,900	7	772	....	1.40	0.16	0.04	11.0	336	....	144+	11.6	89	5.4	1.4	....	....	....	....
Jan. 5–6	78,800	....	804	....	2.00	0.06	0.04	11.0	266	....	144+	11.0	84	7.8	2.0	....	....	....	....
Jan. 8–9	67,000	2	992	....	1.20	0.04	0.04	9.6	324	....	144+	11.6	90	13.0	1.4	....	....	....	....
Jan. 11–12	68,800	....	872	....	2.30	0.12	0.04	9.2	276	....	144+	12.0	89	37.0	0.3	....	....	....	....
Jan. 16–17	74,500	11	1,027	....	3.60	0.20	0.03	9.0	274	....	144+	....	....	35.0	0.0	....	....	....	....
Jan. 19–20	61,600	11	740	....	2.70	0.06	0.01	15.0	326	....	144+	....	....	35.0	3.2	....	....	....	....
Jan. 29–30	57,200	12	740	....	1.20	0.02	0.10	8.0	342	....	144+	....	....	8.2	4.1	....	....	....	....
Feb. 1–2	54,000	....	660	....	1.00	0.16	0.03	8.0	288	....	144+	....	....	24.0	3.0	....	....	....	....
Feb. 6–7	69,000	13	684	....	0.80	0.16	0.03	8.8	336	....	144+	9.8	81	17.0	2.8	....	....	....	....
Feb. 9–10	83,600	3	576	....	1.20	0.02	0.03	4.0	308	....	144+	11.2	79	5.8	4.7	....	....	....	....
Feb. 14–15	60,800	6	700	....	2.00	0.00	0.01	2.3	304	....	144+	11.4	83	6.4	1.7	....	....	....	....
Feb. 19–20	62,700	7	764	....	2.30	0.08	0.04	3.0	348	....	40	9.6	70	12.0	8.4	....	....	....	....
Feb. 22–23	5,200	....	....	....	....	....	....	3.7	....	....	144+	6.6	48	7.0	14.0	....	....	....	....
Mar. 5–6	56,400	8	852	....	1.90	0.30	0.06	10.0	296	....	144+	....	....	26.0	13.0	....	....	....	....
Mar. 8–9	55,900	13	....	....	2.40	0.20	0.14	7.4	284	....	77	10.0	76	24.0	25.0	....	....	....	....
Mar. 13–14	44,800	21	784	....	5.40	0.24	0.20	14.0	312	....	144+	9.6	73	13.0	15.0	....	....	....	....
Mar. 16–17	63,600	6	....	....	....	0.04	0.40	3.6	356	....	90	7.2	56	12.0	12.0	....	....	....	....
Mar. 18–19	67,300	13	....	....	....	0.06	0.15	3.2	220	....	65	....	....	9.0	....	....	....	....	....
Mar. 20–21	67,400	11	744	....	1.00	0.00	0.14	2.0	316	....	28	8.0	64	8.2	13.0	....	....	....	....
Mar. 26–27	64,400	25	....	....	....	0.32	0.18	2.1	256	....	20	6.4	52	14.0	....	....	....	....	....
Mar. 29–30	68,000	42	1,120	....	3.40	0.16	0.75	4.4	420	....	16	....	....	38.0	....	....	....	....	....

DETAILED CHEMICAL AND BACTERIOLOGICAL ANALYSES OF INFLUENT [1] TO SAND FILTER NO. 1.

	Temperature, ° F.			Chemical analyses (p. p. m.).														Bacteria (1,000 per c. c.).	
							Nitrogen as—								Oxygen demand at 20° C.				
	Influent.	Effluent.	Air.	Suspended solids.	Residue on evaporation.	Turbidity.	Total organic.	Ammoniacal.	Nitrites.	Alkalinity.	Acidity.	Chlorides.	Ether soluble matter.	Oxygen consumed: 30 min. 96° C.	24 hours.	5 days.	10 days.	Agar 30° C., 48 hours.	Endo plates, red colonies.
1917.																			
Apr. 3-4	69	45	39	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Apr. 6-7	65	46	32	520	1,348	...	40	1.6	...	...	...	...	214	195	390	913	...	...	...
Apr. 8-9	64	45	28	612	1,720	...	50	10.0	...	...	40	...	203	285	345	...	...	...	...
Apr. 11-12	67	44	45	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
May 3-4	67	51	41	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
May 8-9	68	48	45	280	1,232	...	42	6.0	0.015	...	288	...	18	338	733	1,200	...	...	...
May 13-14	66	50	50	342	...	...	36	16.0	...	...	188	...	42	276	478	1,645	...	...	...
May 18-19	73	59	60	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
May 24-25	62	36	48	220	...	...	32	3.6	0.000	...	180	...	...	231	...	...	...	...	...
May 30-31	75	63	68	160	...	...	26	20.0	...	...	80	...	...	184	580	1,153	1,533	...	...
June 3-4	73	64	60	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
June 6-7	76	65	66	356	...	...	56	8.0	...	...	156	...	...	280	503	1,067	1,400	...	...
June 11-12	76	69	64	136	...	...	20	...	...	...	356	...	...	132	...	...	...	...	...
June 14-15	73	67	59	404	...	...	44	5.6	...	...	108	...	...	236	625	...	...	...	...
June 19-20	77	68	72	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
June 22-23	75	69	74	224	...	...	42	16.0	...	...	140	...	...	230	678	1,053	...	...	...
June 24-25	75	67	64	304	...	...	49	7.2	...	...	292	...	...	339	666	...	...	...	...
June 27-28	78	69	71	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
July 11-12	70	67	64	240	...	...	34	17.0	...	...	348	...	...	238	750	2,300	...	...	...
July 22-23	77	72	74	200	...	...	36	10.0	...	...	346	...	...	177	900	1,575	...	...	...
July 25-26	76	75	80	200	...	...	26	2.0	...	...	360	...	...	220	587	1,489	...	...	...
July 30-31	77	76	80	236	...	...	40	3.4	...	...	450	...	...	224	652	1,419	...	...	...

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[1] Effluent from septic tank.

DETAILED CHEMICAL AND BACTERIOLOGICAL ANALYSES OF EFFLUENT OF SAND FILTER NO. 1.

	Net rate on filter G.A.O.	Chemical analyses (p. p. m.).																Bacteria (1,000 per c. c.).	
					Nitrogen as—							Diss. oxygen.			Oxygen demand at 20° C.				
		Suspended solids.	Residue on evaporation.	Turbidity.	Total organic.	Ammoniacal.	Nitrites.	Nitrates.	Alkalinity.	Acidity.	Putrescibility hours to reduce M. B. at room temperature.	P. P. M.	Per cent sat.	Oxygen consumed: 30 min. 96° C.	24 hours.	5 days.	10 days.	Agar 30° C., 48 hours.	Endo plates, red colonies.
1917.																			
Apr. 3-4	74,500	......	......	......	......	0.04	0.30	2.2	332	......	28	6.8	58	21.0	20.0	58	......	......	......
Apr. 6-7	65,000	26	696	......	4.0	0.04	1.80	0.3	416	......	28	9.0	77	13.0	20.0	38	......	......	......
Apr. 8-9	60,600	21	728	......	1.2	0.80	0.90	4.3	368	......	144+	10.0	90	7.8	......	5	......	......	......
Apr. 11-12	73,800	24	......	......	......	0.06	1.00	6.1	428	......	20	11.0	90	16.0	20.0	20	......	......	......
May 3-4	88,900	10	......	......	......	0.10	0.13	19.0	384	......	16	......	......	35.0	45.0	......	......	......	......
May 8-9	60,600	14	880	......	1.6	0.08	0.16	9.6	426	......	144+	4.4	38	13.0	32.0	......	......	......	......
May 13-14	59,500	20	......	......	1.4	0.06	0.18	5.5	380	......	24	7.8	69	10.0	10.0	24	......	......	......
May 18-19	53,400	3	......	......	......	0.04	0.22	15.0	384	......	144+	4.8	50	6.0	0.4	8	......	......	......
May 24-25	69,000	......	......	......	0.1	0.72	0.42	37.0	296	......	144+	......	......	6.5	......	......	......	......	......
May 30-31	82,300	......	......	......	1.0	0.80	0.25	20.0	396	......	144+	5.0	51	12.0	3.2	9	46	......	......
June 3-4	63,700	......	......	......	2.4	0.60	0.24	25.0	336	......	144+	5.0	52	7.4	1.1	5	14	......	......
June 6-7	67,900	......	......	......	0.80	0.80	0.20	24.0	396	......	144+	4.0	42	4.1	1.3	8	37	......	......
June 11-12	77,100	......	......	......	......	0.48	0.18	28.0	404	......	144+	3.2	34	4.7	1.5	10	......	......	......
June 14-15	76,600	......	......	......	0.30	0.40	0.32	6.4	376	......	144+	6.0	64	4.4	5.4	......	......	......	......
June 19-20	77,100	......	......	......	0.70	0.20	0.13	8.4	344	......	144+	3.4	37	7.6	0.9	6	26	......	......
June 22-23	71,200	......	......	......	1.00	0.24	0.12	6.0	520	......	144+	3.0	33	7.9	1.8	9	......	......	......
June 24-25	63,100	......	......	......	0.90	0.30	0.13	5.0	456	......	144+	3.4	37	7.2	1.8	......	......	......	......
June 27-28	74,200	......	......	......	......	0.16	0.16	3.0	392	......	20	3.0	33	24.0	29.0	......	......	......	......
July 11-12	......	......	......	......	0.20	0.70	0.16	30.0	200	......	144+	2.0	21	16.0	6.2	31	......	......	......
July 22-23	70,000	......	......	......	2.00	1.20	0.02	14.0	269	......	144+	3.2	37	8.6	0.5	16	35	......	......
July 25-26	63,200	......	......	......	0.60	0.40	0.60	20.0	202	......	144+	3.2	38	11.0	4.5	24	37	......	......
July 30-31	69,600	......	......	......	0.80	0.70	0.60	20.0	490	......	144+	2.8	33	8.6	......	22	24	......	......

DETAILED CHEMICAL AND BACTERIOLOGICAL ANALYSES OF INFLUENT[1] TO SAND FILTER NO. 1.

	Temperature, ° F.			Chemical analyses (p. p. m.).														Bacteria (1,000 per c. c.).	
							Nitrogen as—								Oxygen demand at 20° C.				
	Influent.	Effluent.	Air.	Suspended solids.	Residue on evaporation.	Turbidity.	Total organic.	Ammoniacal.	Nitrites.	Alkalinity.	Acidity.	Chlorides.	Ether soluble matter.	Oxygen consumed: 30 min. 96° C.	24 hours.	5 days.	10 days.	Agar 30° C., 48 hours.	Endo plates, red colonies.
1917.																			
Aug. 2- 3......	73	76	76	176	....	....	16	2.4	....	....	188	....	....	189	417	770	1,050	....	....
Aug. 7- 8......	79	74	74	228	....	....	15	5.4	....	....	220	....	....	184	512	918	....	....	....
Aug. 10-11......	75	70	61	292	....	....	28	2.5	....	....	224	....	....	173	575	1,012	1,258	....	....
Aug. 12-13......	76	72	70	212	....	....	44	7.0	....	....	288	....	....	170	....	....	....	....	....
Aug. 15-16......	76	71	68	220	....	....	40	7.4	....	....	100	....	....	118	410	595	1,000	....	....
Aug. 20-21......	77	72	70	152	....	....	34	10.0	....	....	50	....	....	116	603	866	1,125	....	....
Aug. 23-24......	74	68	70	174	....	....	27	0.8	....	....	80	....	....	95	280	675	1,058	....	....
Aug. 28-29......	72	68	68	260	....	....	13	2.6	....	....	128	....	....	180	480	995	975	1,500	200
Sept. 1......	73	68	70	72	....	....	19	9.0	....	....	144	....	....	95	530	866	1,408	....	....
Sept. 2- 3......	72	66	66	488	....	....	22	5.8	....	....	324	....	....	154	....	....	....	....	....
Sept. 6- 7......	72	63	54	272	....	....	41	9.5	....	....	480	....	....	216	430	1,775	2,435	....	....
Sept. 10-11......	70	60	49	200	....	....	21	2.8	....	....	160	....	....	207	20	500	600	20,900	18,200
Sept. 13-14......	72	60	50	356	....	....	49	1.0	....	....	140	....	....	281	487	1,000	1,290	42,000	....
Sept. 18-19......	73	61	55	272	....	....	56	4.0	....	....	100	....	....	363	40	1,008	1,141	14,200	11,700
Sept. 21-22......	73	62	56	148	....	....	42	2.0	....	....	72	....	....	159	30	775	1,266	9,300	8,000
Sept. 23-24......	72	61	48	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Sept. 26-27......	72	59	48	56	....	....	44	4.4	....	....	160	....	....	187	335	350	891	18,000	17,000
Oct. 1- 2......	71	58	46	240	....	....	36	8.0	....	....	228	....	....	177	45	750	1,283	34,000	24,000
Oct. 4- 5......	73	56	52	120	....	....	57	2.8	....	....	496	....	....	282	10	1,667	2,350	6,200	....
Oct. 9-10......	70	50	37	....	....	....	63	5.0	....	....	428	....	....	256	140	991	1,666	1,520	390
Oct. 17-18......	69	50	48	236	....	....	48	8.0	....	....	348	....	....	178	405	733	1,525	....	....
Oct. 22-23......	59	46	36	176	....	....	68	12.0	....	....	112	....	....	223	220	650	700	....	....

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[1] Effluent from septic tank.

DETAILED CHEMICAL AND BACTERIOLOGICAL ANALYSES OF EFFLUENT OF SAND FILTER NO. 1.

	Net rate on filter G.A.O.	Chemical analyses (p. p. m.).																Bacteria (1,000 per c. c.).	
		Sus-pended solids.	Resi-due on evapo-ration.	Tur-bidity.	Nitrogen as—				Alka-linity.	Acid-ity.	Putres-cibility hours to re-duce M. B. at room tem-pera-ture.	Diss. oxygen.		Oxy-gen con-sumed: 30 min. 96° C.	Oxygen demand at 20° C.				
					Total or-ganic.	Am-mo-niacal.	Ni-trites.	Ni-trates.				P. P. M.	Per cent sat.		24 hours.	5 days.	10 days.	Agar 30° C., 48 hanrt.	Endo plates, red col-onies.
1917.																			
Aug. 2- 3	85,700	....	....	....	1.4	0.00	0.20	28.0	372	....	+144	4.9	58	5.4	0.2	17	52	....	....
Aug. 7- 8	83,200	....	....	....	1.6	0.40	0.06	25.0	372	....	+144	3.0	35	5.1	1.0	22	39	72.0	....
Aug. 10-11	66,700	....	....	....	0.8	0.20	0.06	16.0	400	....	+144	4.1	48	4.0	2.2	12	13	2.0	....
Aug. 12-13	76,000	....	....	....	1.4	0.60	0.06	12.0	410	....	+144	5.6	64	4.3	1.4	39	62	6.0	....
Aug. 15-16	77,800	....	....	....	0.6	....	0.10	15.0	380	....	+144	5.4	61	4.4	1.3	15	40	8.0	....
Aug. 20-21	82,800	5	....	....	0.1	0.10	0.06	20.0	406	....	+144	5.8	66	5.6	0.6	20	27	10.0	2.00
Aug. 23-24	78,900	....	....	....	2.5	0.15	0.22	20.0	424	....	+144	5.3	60	3.8	1.8	9	28	5.0	6.00
Aug. 28-29	83,800	....	....	....	....	....	....	12.0	440	....	+144	7.0	76	2.4	2.2	14	26	5.0	4.00
Sept. 1	78,700	....	....	....	0.4	0.20	....	5.0	440	....	+144	5.7	62	4.0	3.5	12	27	....	....
Sept. 2- 3	83,000	....	....	....	0.6	....	....	10.0	340	....	+144	7.3	78	4.7	0.3	20	21	1.2	0.04
Sept. 6- 7	82,800	....	....	....	0.3	....	....	10.0	440	....	+144	6.7	69	4.6	4.5	14	27	94.0	32.00
Sept. 10-11	80,400	....	....	....	0.2	....	....	6.0	436	....	+144	7.3	72	3.4	0.8	12	11	....	....
Sept. 13-14	76,800	....	....	....	0.4	....	....	3.0	404	....	+144	7.2	71	5.0	3.0	10	19	460.0	400.00
Sept. 18-19	81,800	30	....	....	0.8	0.20	....	4.0	448	....	+144	7.5	75	9.0	7.0	21	....	7.3	4.70
Sept. 21-22	85,100	....	....	....	0.4	....	....	4.0	404	....	+144	6.1	61	8.0	4.7	12	16	161.0	100.00
Sept. 23-24	88,500	....	....	....	2.0	....	....	6.0	410	....	+144	6.6	66	2.7	....	8	18	73.0	32.00
Sept. 26-27	81,000	....	....	....	0.2	....	....	7.5	520	....	+144	7.1	70	4.6	2.1	8	26	0.9	....
Oct. 1- 2	81,200	....	....	....	0.2	....	0.04	4.0	420	....	+144	6.2	60	4.2	4.0	17	....	220.0	330.00
Oct. 4- 5	78,400	....	....	....	2.4	....	0.02	2.4	224	....	28	4.2	39	13.0	10.0	....	....	700.0	....
Oct. 9-10	49,700	....	....	....	1.8	0.20	....	2.0	456	....	32	5.6	49	9.8	38.0	59	82	25.0	3.30
Oct. 17-18	44,800	....	....	....	2.0	0.40	....	....	536	....	20	5.2	47	6.2	50.0	....	82	80.0	....
Oct. 22-23	30,100	....	....	....	2.2	0.20	....	....	292	....	+144	7.8	66	3.7	3.0	6	10	3.0	1.00

DETAILED CHEMICAL AND BACTERIOLOGICAL ANALYSES OF INFLUENT [1] TO SAND FILTER NO. 2.

	Temperature, ° F.			Chemical analyses (p. p. m.).														Bacteria (1,000 per c. c.).	
							Nitrogen as—								Oxygen demand at 20° C.				
	Influent.	Effluent.	Air.	Suspended solids.	Residue on evaporation.	Turbidity.	Total organic.	Ammoniacal.	Nitrites.	Alkalinity.	Acidity.	Chlorides.	Ether soluble matter.	Oxygen consumed: 30 min. 96° C.	24 hours.	5 days.	10 days.	Agar 30° C., 48 hours.	Endo plates, red colonies.
1916.																			
May 16–17	72	59	56	104	....	900	138	22.0	0.020	....	432	....	....	1,600	....	....	....	....	....
May 19–20	72	54	49	266	2,920	510	78	14.0	....	....	684	....	....	1,170	1,830	....	....	....	....
May 22–23	74	57	57	214	....	500	107	13.0	....	....	860	....	....	940	....	....	....	....	....
May 25–26	79	65	62	364	2,352	700	100	22.0	.200	....	560	....	....	1,900	3,100	....	....	....	....
June 8–9	68	63	62	344	2,700	900	160	20.0	.020	....	576	....	....	650	1,740	....	....	....	....
June 13–14	74	63	61	152	2,772	940	131	9.2	.040	....	520	....	....	500	1,410	....	....	....	....
June 15–16	73	65	64	244	2,800	860	100	16.0	.020	....	496	....	....	270	1,120	....	....	....	....
June 27–28	72	64	64	180	1,792	400	70	38.0	.130	....	272	....	....	295	1,220	....	....	....	....
July 1–2	75	66	66	240	1,720	500	60	12.0	.020	....	160	....	....	290	1,090	....	....	....	....
July 3	70	66	66	280	1,728	365	74	22.0	.010	....	204	....	....	370	1,080	....	....	....	....
July 6–7	76	65	65	360	1,288	380	74	11.0	.010	....	264	....	....	230	860	....	....	....	....
July 11–12	79	72	75	178	1,496	550	36	20.0	.010	....	180	....	....	208	780	....	....	....	....
July 14–15	79	75	73	132	1,552	350	46	50.0	.020	....	148	....	....	164	1,060	....	....	....	....
July 17–18	76	75	71	176	1,676	435	40	32.0	.020	....	208	....	....	190	960	....	....	....	....
July 20–21	79	75	72	236	1,552	470	43	28.0	.020	....	192	....	....	172	680	....	....	....	....
July 25–26	78	73	70	352	1,748	1,000	60	40.0	....	....	172	....	....	236	1,100	....	....	....	....
July 28–29	79	74	71	286	1,680	650	58	18.0	....	....	....	....	....	226	760	....	....	....	....
Aug. 1–2	78	75	67	276	1,420	670	47	19.0	....	....	168	....	....	212	600	....	....	....	....
Aug. 3–4	78	74	69	188	1,580	950	50	33.0	....	....	....	....	....	176	800	....	....	....	....
Aug. 8–9	75	73	68	304	1,600	1,200	81	15.0	....	....	192	....	....	172	760	....	....	....	....
Aug. 11–12	77	73	68	452	1,692	1,100	91	25.0	....	....	184	....	....	239	800	....	....	....	....
Aug. 14–15	75	65	59	280	1,700	1,100	62	10.0	....	....	192	....	....	236	610	....	....	....	....
Aug. 17–18	80	69	63	248	1,948	1,000	78	30.0	....	....	92	....	....	177	680	....	....	....	....
Aug. 21–22	79	74	71	182	1,532	750	....	30.0	....	....	40	....	....	148	640	....	....	....	....
Aug. 24–25	77	69	58	324	2,172	1,100	36	22.0	....	....	152	....	....	430	820	....	....	....	....
Aug. 28–29	70	65	52	232	2,148	1,300	50	23.0	....	....	306	....	....	336	460	....	....	....	....
Aug. 30–31	76	63	56	268	1,980	1,100	66	14.0	....	....	304	....	....	332	833	....	....	....	....

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[1] Effluent from septic tank.

DETAILED CHEMICAL AND BACTERIOLOGICAL ANALYSES OF EFFLUENT OF SAND FILTER NO. 2.

	Net rate on filter G.A.O.	Chemical analyses (p. p. m.).																Bacteria (1,000 per c. c.).	
		Suspended solids.	Residue on evaporation.	Turbidity.	Nitrogen as—				Alkalinity.	Acidity.	Putrescibility hours to reduce M. B. at room temperature.	Diss. oxygen.		Oxygen consumed: 30 min. 96° C.	Oxygen demand at 20° C.				
					Total organic.	Ammoniacal.	Nitrites.	Nitrates.				P. P. M.	Per cent sat.		24 hours.	5 days.	10 days.	Agar 30° C., 48 hours.	Endo plates, red colonies.
1916.																			
May 16-17	26,900	4	....	60	4.0	140.0	6.0	14.0	280	....	144+	1.8	17	65.0	24.0	....	....	....	....
May 19-20	23,000	24	1,024	25	....	105.0	6.0	40.0	300	....	144+	3.1	30	30.0	11.0	....	....	....	....
May 22-23	29,400	30	....	53	8.0	80.0	8.8	64.0	220	....	22	....	....	61.0	....	....	....	....	....
May 25-26	25,000	4	1,540	20	10.0	50.0	9.5	65.0	328	....	144+	.6	6	46.0	33.0	....	....	....	....
June 8-9	23,500	8	2,336	40	20.0	20.0	30.0	120.0	141	....	144+	1.4	14	86.0	54.0	....	....	....	....
June 13-14	25,600	10	2,904	46	22.0	18.0	35.0	100.0	132	....	144+	1.2	12	61.0	6.0	....	....	....	....
June 15-16	25,000	6	2,808	20	5.0	15.0	32.0	72.0	156	....	144+	4.8	52	46.0	22.0	....	....	....	....
June 27-28	29,400	6	2,684	25	7.6	8.4	32.0	120.0	212	....	144+	2.9	31	47.0	10.0	....	....	....	....
July 1-2	29,500	20	3,432	20	3.2	4.8	21.0	110.0	248	....	144+	2.2	25	40.0	18.0	....	....	....	....
July 3	30,800	36	1,740	36	.6	3.8	12.0	60.0	248	....	144+	2.4	26	34.0	14.0	....	....	....	....
July 6-7	33,200	12	2,028	30	2.4	1.6	6.0	108.0	260	....	144+	2.1	21	28.0	16.0	....	....	....	....
July 11-12	37,700	12	1,340	30	.2	0.2	.8	48.0	328	....	144+	1.6	18	37.0	6.8	....	....	....	....
July 14-15	45,000	18	1,288	20	.4	.4	.8	50.0	344	....	144+	3.1	37	39.0	78.0	....	....	....	....
July 17-18	40,700	7	1,480	25	1.5	.7	1.1	30.0	325	....	144+	1.8	21	22.0	40.0	....	....	....	....
July 20-21	67,400	7	1,520	30	.2	.4	2.2	56.0	312	....	144+	1.5	24	25.0	75.0	....	....	....	....
July 25-26	46,900	5	1,064	15	.2	.1	2.0	25.0	348	....	144+	2.2	26	19.0	23.0	....	....	....	....
July 28-29	67,400	4	1,064	10	1.4	.4	.4	27.0	324	....	144+	2.7	32	13.0	8.0	....	....	....	....
Aug. 1-2	72,900	10	1,156	15	.1	.1	2.1	38.0	288	....	144+	2.6	30	22.0	16.0	....	....	....	....
Aug. 3-4	66,200	2	984	5	.3	.5	.5	18.0	316	....	144+	2.3	27	8.0	4.0	....	....	....	....
Aug. 8-9	75,500	1	1,300	4	1.0	.4	.4	37.0	308	....	144+	3.3	38	6.0	4.6	....	....	....	....
Aug. 11-12	77,600	9	1,100	20	3.3	.2	2.0	14.0	344	....	49	3.6	41	12.0	50.0	....	....	....	....
Aug. 14-15	73,900	13	1,032	5	.3	.5	.3	20.0	304	....	144+	3.5	38	5.0	6.0	....	....	....	....
Aug. 17-18	79,800	9	1,280	15	3.5	.2	.8	9.6	424	....	75	3.1	35	13.0	13.0	....	....	....	....
Aug. 21-22	71,700	4	1,252	10	.3	.4	.5	24.0	296	....	144+	3.5	39	8.0	6.0	....	....	....	....
Aug. 24-25	76,600	15	1,240	5	....	.4	.2	16.0	284	....	144+	4.3	47	6.0	3.8	....	....	....	....
Aug. 28-29	67,300	3	1,336	5	1.0	.1	.2	12.0	400	....	144+	3.5	37	14.0	14.0	....	....	....	....
Aug. 30-31	82,700	4	1,440	5	1.0	.1	.8	4.4	472	....	144+	3.4	36	10.0	12.0	....	....	....	....

DETAILED CHEMICAL AND BACTERIOLOGICAL ANALYSES OF INFLUENT[1] TO SAND FILTER NO. 2.

	Temperature, ° F.			Chemical analyses (p. p. m.).														Bacteria (1,000 per c. c.).	
							Nitrogen as—								Oxygen demand at 20° C.				
	Influent.	Effluent.	Air.	Suspended solids.	Residue on evaporation.	Turbidity.	Total organic.	Ammoniacal.	Nitrites.	Alkalinity.	Acidity.	Chlorides.	Ether soluble matter.	Oxygen consumed: 30 min. 96° C.	24 hours.	5 days.	10 days.	Agar 30° C., 48 hours.	Endo plates, red colonies.
1916.																			
Sept. 5-6	76	66	67	320	1,976	1,100	......	41.0	0.010	......	240	......	......	174	875	......	......	......	......
Sept. 8-9	72	68	58	176	1,364	800	40	33.0	0.020	......	100	......	......	177	658	......	......	......	......
Sept. 11-12	74	65	59	228	2,036	1,200	50	23.0	0.010	......	144	......	......	282	473	......	......	......	......
Sept. 14-15	73	65	62	768	3,808	1,200	125	35.0	0.020	......	496	......	......	840	553	......	......	......	......
Sept. 19-20	66	54	43	258	1,929	1,100	63	17.0	0.020	......	256	......	......	224	300				
Sept. 22-23	69	56	55	284	1,616	1,000	68	28.0	0.020	......	136	......	......	175	573	......	......	......	......
Oct. 25	......	......	......	......	......	......	......	......	......	......	......	......	......	......	560	......	......	......	......
Oct. 25-26	65	45	44	352	1,896	800	42	18.0	0.010	......	20	......	......	240	......	......	......	......	......
Oct. 27	65	45	34	......	......	......	......	......	......	......	......	......	......	......	395	......	......	......	......
Oct. 30-31	66	66	42	204	1,360	800	28	36.0	0.005	......	60	......	......	124	570	......	......	......	......
Nov. 1-2	65	47	40	......	......	......	......	......	......	......	......	......	......	......	670	......	......	......	......
Nov. 2-3	64	46	34	296	1,616	800	37	17.0	0.005	......	......	......	......	149	......	......	......	......	......
Nov. 4	64	46	40	......	......	......	......	......	......	......	......	......	......	......	480	......	......	......	......
Nov. 13-14	42	43	32	164	1,288	650	34	36.0	0.005	......	224	......	......	161	580	......	......	......	......
Nov. 15-16	62	39	21	......	......	......	......	......	......	......	......	......	......	......	470	......	......	......	......
Nov. 16-17	62	39	25	320	2,400	800	70	15.0	0.010	......	452	......	......	320	......	......	......	......	......
Nov. 18	63	39	26	......	......	......	......	......	......	......	......	......	......	......	525	......	......	......	......
Nov. 19-20	63	......	40	304	1,444	......	52	14.0	......	......	76	......	......	142	535	......	......	......	......
Nov. 22	62	39	26	......	......	......	......	......	......	......	......	......	......	......	940	......	......	......	......
Nov. 22-23	64	39	26	232	1,296	......	48	22.0	......	......	308	......	......	149	......	......	......	......	......
Nov. 28	61	39	42	......	......	......	......	......	......	......	......	......	......	......	535	......	......	......	......
Nov. 28-29	64	41	47	312	1,524	......	36	14.0	0.005	......	160	280	......	287	......	......	......	......	......

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[1] Effluent from septic tank.

DETAILED CHEMICAL AND BACTERIOLOGICAL ANALYSES OF EFFLUENT OF SAND FILTER NO. 2.

	Net rate on filter G.A.O.	Chemical analyses (p. p. m.).																Bacteria (1,000 per c. c.).	
		Suspended solids.	Residue on evaporation.	Turbidity.	Nitrogen as—				Alkalinity.	Acidity.	Putrescibility hours to reduce M. B. at room temperature.	Diss. oxygen.		Oxygen consumed: 30 min. 96° C.	Oxygen demand at 20° C.			Agar 30° C., 48 hours.	Endo plates, red colonies.
					Total organic.	Ammoniacal.	Nitrites.	Nitrates.				P. P. M.	Per cent sat.		24 hours.	5 days.	10 days.		
1916.																			
Sept. 5–6	73,100	2	1,524	8	0.40	0.20	1.30	4.0	448	....	144+	2.8	30	7.0	9.0	....	....	....	....
Sept. 8–9	71,900	9	1,172	5	1.50	0.10	1.40	14.0	460	....	144+	2.2	24	8.0	13.0	....	....	....	....
Sept. 11–12	67,800	8	1,516	10	2.00	0.60	1.30	22.0	332	....	144+	2.2	23	11.0	8.0	....	....	....	....
Sept. 14–15	66,800	4	1,432	10	0.60	0.40	2.00	12.0	380	....	140	2.0	21	23.0	11.0	....	....	....	....
Sept. 19–20	72,500	4	1,308	10	0.20	0.10	1.20	7.0	452	....	144+	5.2	48	7.0	10.0	....	....	....	....
Sept. 22–23	74,600	....	1,196	5	0.10	0.10	0.50	10.0	436	....	144+	3.0	29	4.0	5.0	....	....	....	....
Oct. 25	54,600	11	1,256	20	0.50	0.10	0.08	18.0	340	....	144+	6.2	53	9.8	....	....	....	....	....
Oct. 25–26	60,100	11	1,256	20	0.50	0.10	0.08	18.0	340	....	144+	6.2	53	9.8	....	....	....	....	....
Oct. 27	53,300	....	....	....	....	....	....	....	....	....	144+	7.2	61	....	2.2	....	....	....	....
Oct. 30–31	65,000	21	1,330	20	0.70	0.10	0.22	7.0	340	....	144+	7.4	64	7.8	2.8	....	....	....	....
Nov. 1–2	74,500	....	....	....	....	....	....	....	....	....	144+	5.2	45	....	3.9	....	....	....	....
Nov. 2–3	73,200	6	1,308	5	0.10	0.10	0.06	7.0	320	....	144+	....	....	4.2	....	....	....	....	....
Nov. 4	74,000	....	....	....	....	....	....	....	....	....	144+	6.2	53	....	7.1	....	....	....	....
Nov. 13–14	71,600	12	1,088	8	0.32	0.16	0.40	25.0	308	....	144+	10.0	84	6.2	6.0	....	....	....	....
Nov. 15–16	65,000	....	....	....	....	....	....	....	....	....	144+	9.8	76	....	2.2	....	....	....	....
Nov. 16–17	59,800	4	1,136	3	0.12	0.04	0.12	16.0	320	....	144+	....	....	6.6	....	....	....	....	....
Nov. 18	43,700	....	....	....	....	....	....	....	....	....	....	....	....	....	1.8	....	....	....	....
Nov. 19–20	42,800	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Nov. 22	80,100	....	....	....	....	....	....	....	....	....	105+	12.0	94	....	7.4	....	....	....	....
Nov. 22–23	69,500	54	1,308	....	4.80	3.20	0.75	1.5	220	....	....	....	....	....	....	....	....	....	....
Nov. 28	74,800	....	....	....	....	....	....	....	....	....	40	....	....	....	....	....	....	....	....
Nov. 28–29	71,000	7	824	....	0.76	0.12	0.02	8.0	328	....	92	....	....	11.0	....	....	....	....	....

DETAILED CHEMICAL AND BACTERIOLOGICAL ANALYSES OF INFLUENT [1] TO SAND FILTER NO. 2.

	Temperature, ° F.			Chemical analyses (p. p. m.).														Bacteria (1,000 per c. c.).	
							Nitrogen as—								Oxygen demand at 20° C.				
	Influent.	Effluent.	Air.	Suspended solids.	Residue on evaporation.	Turbidity.	Total organic.	Ammoniacal.	Nitrites.	Alkalinity.	Acidity.	Chlorides.	Ether soluble matter.	Oxygen consumed: 30 min. 96° C.	24 hours.	5 days.	10 days.	Agar 30° C., 48 hours.	Endo plates, red colonies.
1916–17.																			
Dec. 1–2	64	45	30	408	1,924	....	58	22.0	....	....	216	224	....	437	775	....	....	....	....
Dec. 3–4	68	46	48	372	2,044	....	51	35.0	....	....	496	408	....	386	710	....	....	....	....
Dec. 6–7	68	47	29	324	1,756	....	42	38.0	....	....	104	392	....	202	660	....	....	....	....
Dec. 11–12	65	52	31	220	1,044	....	34	16.0	....	....	24	182	....	184	330	....	....	....	....
Dec. 14–15	62	43	14	128	1,324	....	26	18.0	0.005	....	40	326	....	63	145	....	....	....	....
Dec. 22–23	64	40	24	265	1,156	....	18	18.0	.005	....	48	446	....	72	425	....	....	....	....
Dec. 25–26	61	37	22	556	1,304	....	55	21.0	....	....	72	154	....	169	410	....	....	....	....
Dec. 29	66	....	20	....	....	....	....	....	....	....	....	....	....	....	720	....	....	....	....
Jan. 2–3	65	36	35	368	1,372	....	65	5.0	.010	....	132	416	....	240	475	....	....	....	....
Jan. 5–6	68	38	44	324	1,720	....	56	14.0	.010	....	64	418	....	168	620	....	....	....	....
Jan. 8–9	66	41	34	272	1,276	....	28	16.0	.050	....	80	232	....	169	510	....	....	....	....
Jan. 11–12	64	38	8	328	1,220	....	63	7.0	.010	....	....	....	....	195	350	....	....	....	....
Jan. 16–17	67	37	6	292	1,039	....	75	9.0	.015	....	106	124	34	222	660	....	....	....	....
Jan. 19–20	64	36	25	232	1,116	....	50	17.0	.005	....	172	90	77	241	680	....	....	....	....
Jan. 24–25	70	....	18	328	1,756	....	37	17.0	.020	....	292	....	10	272	910	....	....	....	....
Jan. 29–30	65	39	38	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Feb. 1–2	63	36	18	368	1,652	....	35	11.0	.015	....	....	....	160	257	648	....	....	....	....
Feb. 6–7	64	36	17	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Feb. 9–10	64	34	5	172	956	....	33	11.0	.050	....	....	....	81	151	444	....	....	....	....
Feb. 14–15	66	36	17	380	1,588	....	58	6.0	....	....	96	....	53	358	545	....	....	....	....
Feb. 19–20	66	36	34	236	1,160	....	52	12.0	....	....	180	....	33	264	610	....	....	....	....

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[1] Effluent from septic tank.

DETAILED CHEMICAL AND BACTERIOLOGICAL ANALYSES OF EFFLUENT OF SAND FILTER NO. 2.

	Net rate on filter G.A.O.	Chemical analyses (p. p. m.).																Bacteria (1,000 per c. c.).	
		Suspended soiids.	Residue on evaporation.	Turbidity.	Nitrogen as—				Alkalinity.	Acidity.	Putrescibility hours to reduce M. B. at room temperature.	Diss. oxygen.		Oxygen consumed: 30 min. 96° C.	Oxygen demand at 20° C.				
					Total organic.	Ammoniacal.	Nitrites.	Nitrates.				P. P. M.	Per cent sat.		24 hours.	5 days.	10 days.	Agar 30° C., 48 hours.	Endo plates, red colonies.
1916–17.																			
Dec. 1– 2	56,600	3	904	....	0.74	0.06	0.12	6.0	372	....	57	11.0	88	9.6	....	....	....	....	....
Dec. 3– 4	54,800	8	912	....	.56	.04	.04	5.0	404	....	144+	8.2	67	7.2	1.0	....	....	....	....
Dec. 6– 7	62,300	6	1,208	....	1.40	.04	.02	2.3	488	....	144+	8.8	75	5.4	2.1	....	....	....	....
Dec. 11–12	71,800	3	1,072	....	.86	.10	.08	4.5	344	....	144+	9.0	81	5.6	.8	....	....	....	....
Dec. 14–15	61,900	....	1,084	....	.68	.20	.10	10.0	268	....	144+	10.0	83	5.6	....	....	....	....	....
Dec. 22–23	59,200	3	976	....	2.00	.24	.05	9.6	288	....	144+	10.4	83	3.8	1.8	....	....	....	....
Dec. 25–26	50,200	4	920	....	2.20	.24	.06	10.0	300	....	144+	....	....	6.4	1.4	....	....	....	....
Dec. 29	50,200	....	....	....	....	....	....	....	....	....	144+	....	....	....	....	....	....	....	....
Jan. 2– 3	70,900	13	808	....	2.40	.80	.28	8.0	320	....	24	5.8	43	16.0	26.0	....	....	....	....
Jan. 5– 6	84,800	....	740	....	2.20	.16	.04	5.6	320	....	144+	11.0	86	5.6	2.4	....	....	....	....
Jan. 8– 9	77,400	3	936	....	.56	.08	.30	4.5	340	....	97	9.6	76	9.0	8.5	....	....	....	....
Jan. 11–12	73,200	11	772	....	1.60	.08	.15	4.7	350	....	84	11.0	82	11.0	11.0	....	....	....	....
Jan. 16–17	86,300	14	1,258	....	1.20	.08	.14	3.0	364	....	80	....	....	8.2	....	....	....	....	....
Jan. 19–20	73,800	14	764	....	2.00	.04	.04	2.5	396	....	140	....	....	6.8	5.8	....	....	....	....
Jan. 24–25	43,600	40	1,204	....	1.30	.32	.40	0.5	550	....	....	....	....	25.0	....	....	....	....	....
Jan. 29–30	60,000	23	912	....	1.70	.22	.08	6.0	416	....	20	....	....	11.0	74.0	....	....	....	....
Feb. 1– 2	....	....	1,004	....	1.20	.04	.10	.1	496	....	21	....	....	11.0	28.0	....	....	....	....
Feb. 6– 7	80,500	42	840	....	1.20	2.80	.04	.9	368	....	24	6.8	49	29.0	53.0	....	....	....	....
Feb. 9–10	22,000	21	572	....	4.40	2.00	.10	1.6	376	....	16	11.0	79	12.0	30.0	....	....	....	....
Feb. 14–15	40,000	34	788	....	3.60	2.40	.09	.7	260	....	20	9.8	69	37.0	75.0	....	....	....	....
Feb. 19–20	20,800	19	780	....	2.40	1.60	.10	4.0	352	....	80	10.0	73	9.0	7.2	....	....	....	....

DETAILED CHEMICAL AND BACTERIOLOGICAL ANALYSES OF INFLUENT[1] TO SAND FILTER NO. 2.

	Temperature, ° F.			Chemical analyses (p. p. m.).														Bacteria (1,000 per c. c.).	
							Nitorgen as—								Oxygen demand at 20° C.				
	Influent.	Effluent.	Air.	Suspended solids.	Residue on evaporation.	Turbidity.	Total organic.	Ammoniacal.	Nitrites.	Alkalinity.	Acidity.	Chlorides.	Ether soluble matter.	Oxygen consumed: 30 min. 96° C.	24 hours.	5 days.	10 days.	Agar 30° C., 48 hours.	Endo plates, red colonies.
1917.																			
Mar. 5-6	65	36	12	428	1,448		67	5.0	0.015		140		32	323	410				
Mar. 8-9	66	37	35																
Mar. 13-14	64	39	35	408	1,720		27	18.0			8		115	154	580				
Mar. 16-17	66	41	38																
Mar. 20-21	68	41	38	568	1,428		45	4.5			216		68	308					
Mar. 22	72	41	32												818				
Mar. 26-27	68	45	41																
Mar. 29-30	68	43	37	656	1,992		66	7.5	.025		200		91	315					
Apr. 3-4	68	46	39																
Apr. 6-7	67	46	20	520	1,348		40	1.6					214	195	390	913			
Apr. 8-9	64	48	28	612	1,720		50	10.0			40		203	285	345				
Apr. 11-12	71	44	45																
May 3-4	65	51	41																
May 8-9	68	48	45	280	1,232		42	6.0	.015		288		18	338	733	1,200			
May 13-14	66	50	50	342			36	16.0			188		42	276	478	1,645			
May 18-19	75	61	60																
May 24-25	71	57	48	220			32	3.6			180			231					
May 30-31	73	64	68	160			26	20.0			80			184	580	1,153	1,533		
June 3-4	73	64	60																
June 6-7	76	65	66																
June 8	76	65	67	356			56	8.0			156			280	503	1,067	1,400		
June 11-12	76	70	64	136			20		.010		356			132					
June 14-15	73	65	59	404			44	5.6			108			236	625				
June 19-20	77	68	72																
June 22-23	75	69	74	224			42	16.0			140			230	678	1,053			
June 24-25	75	66	65	304			49	7.2			292			339	666				
June 27-28	78	69	68																

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[1] Effluent from septic tank.

DETAILED CHEMICAL AND BACTERIOLOGICAL ANALYSES OF EFFLUENT OF SAND FILTER NO. 2.

	Net rate on filter G. A. O.	Chemical analyses (p. p. m.).																Bacteria (1,000 per c. c.).	
		Sus-pended solids.	Resi-due on evapo-ration.	Tur-bidity.	Nitrogen as—				Alka-linity.	Acid-ity.	Putres-cibility hours to re-duce M. B. at room tem-pera-ture.	Diss. oxygen.		Oxy-gen con-sumed: 30 min. 96° C.	Oxygen demand at 20° C.				
					Total or-ganic.	Am-mo-niacal.	Ni-trites.	Ni-trates.				P. P. M.	Per cent sat.		24 hours.	5 days.	10 days.	Agar 30° C., 48 hours.	Endo plates, red col-onies.
1917.																			
Mar. 5-6	61,300	24	788		2.40	0.60	.62	9.0	248		144+			29.0	38.0				
Mar. 8-9	66,800	17			1.80	.12	.12	2.2	332		16	9.8	73	16.0	20.0				
Mar. 13-14	38,300	37	1,120		8.00	4.20	.18		404		96	6.4	49	22.0	98.0				
Mar. 16-17	67,300	42				1.10	.02		392		24	7.4	59	17.0	51.0				
Mar. 20-21	70,300	37	784		1.60	.04	.75	.4	324		40			10.0					
Mar. 22	69,000										40	8.2	66		26.0				
Mar. 26-27	69,300	27				.16	.18	1.8	248		24	6.8	55	11.0	54.0				
Mar. 29-30	70,600	51	1,184		3.80	.16	.75	.2	436		16			50.0					
Apr. 3-4	71,100					.12	.40		448		16	4.8	42	55.0	69.0	140			
Apr. 6-7	62,300	32	688		4.40	.04	1.00		424		20	7.0	60	13.0					
Apr. 8-9	61,100	68	828		2.00	.24	1.00	.8	416		16	9.0	77	34.0	10.0	80			
Apr. 11-12	77,000	56				.20	.02		468		16	6.6	56	38.0	35.0				
May 3-4	104,000	18				.40	.13	13.0	376		28			48.0	64.0				
May 8-9	61,700	23	836		2.20	.08	.12	4.4	472		117	4.0	34	18.0					
May 13-14	64,200	36			3.00	.08			400		16	6.6	59	29.0	43.0	114			
May 18-19	52,900	37				.10	.03	.2	312		68	3.4	36	30.0	41.0	84			
May 24-25	56,700				2.50	9.50	.40	.2	360		144+			26.0					
May 30-31	53,800				10.00	30.00	.41	11.0	340		144+	4.8	49	23.0	19.0	74	220		
June 3-4	66,200				3.40	15.00	.32	45.0	400		144+	3.2	34	12.0	42.0	56	243		
June 6-7	73,500	23			3.20	6.40	.55	37.0	344		144+	3.4	36	19.0	18.0	50	91		
June 11-12	78,700					6.40	.24	3.4	468		40	4.2	44	15.0	48.0	103			
June 14-15	69,900				1.40	5.00	.90	18.0	400		144+	2.8	29	12.0	27.0				
June 19-20	75,300				4.40	2.60	1.60	19.0	400		144+	2.4	26	15.0	11.0	26	92		
June 22-23	70,400	16			1.30	3.20	.40	20.0	468		144+	1.4	15	13.0	17.0	33			
June 24-25	62,100				2.50	4.20	.53	12.0	456		144+	1.8	20	16.0	19.0				
June 27-28	76,800					2.00	.28	22.0	444		144+	2.2	24	13.0	12.0				

DETAILED CHEMICAL AND BACTERIOLOGICAL ANALYSES OF INFLUENT [1] TO SAND FILTER NO. 2.

	Temperature, ° F.			Chemical analyses (p. p. m.).														Bacteria (1,000 per c. c.).	
							Nitorgen as—								Oxygen demand at 20° C.				
	Influent.	Effluent.	Air.	Suspended solids.	Residue on evaporation.	Turbidity.	Total organic.	Ammoniacal.	Nitrites.	Alkalinity.	Acidity.	Chlorides.	Ether soluble matter.	Oxygen consumed: 30 min. 96° C.	24 hours.	5 days.	10 days.	Agar 30° C., 48 hours.	Endo plates, red colonies.
1917.																			
July 11-12	70	66	64	240	....	....	34	17.0	....	....	348	....	....	238	750	2,300	....	....	....
July 22-23	77	72	74	200	....	....	36	10.0	....	....	346	....	....	177	900	1,575	....	....	....
July 25-26	76	75	80	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
July 30-31	77	76	80	236	....	....	40	3.4	....	....	450	....	....	224	652	1,419	....	....	....
Aug. 2- 3	73	76	76	176	....	....	16	2.4	....	....	188	....	....	189	417	770	1,050	....	....
Aug. 7- 8	78	74	74	228	....	....	15	5.4	....	....	220	....	....	184	512	918	....	....	....
Aug. 10-11	75	70	61	292	....	....	28	2.5	....	....	224	....	....	173	575	1,012	1,258	....	....
Aug. 12-13	77	72	66	212	....	....	44	7.0	....	....	288	....	....	170	....	....	....	....	....
Aug. 15-16	76	71	68	220	....	....	40	7.4	....	....	100	....	....	118	410	595	1,000	....	....
Aug. 20-21	77	71	70	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Aug. 23-24	74	68	70	174	....	....	27	.8	....	....	80	....	....	95	280	675	1,058	....	....
Aug. 26-27	73	68	64	....	....	....	....	....	....	....	....	....	....	....	480	995	....	1,500	201
Aug. 28-29	72	68	68	260	....	....	13	2.6	....	....	128	....	....	180	....	....	....	587	....
Aug. 31 Sept. 1	73	66	66	72	....	....	19	9.0	....	....	144	....	....	95	530	866	1,408	300	509
Sept. 2- 3	72	66	66	488	....	....	22	5.8	....	....	324	....	....	154	....	....	....	....	....
Sept. 6- 7	72	64	54	272	....	....	41	9.5	....	....	480	....	....	216	430	1,775	2,435	....	....
Sept. 10-11	70	61	49	200	....	....	21	2.8	....	....	160	....	....	207	20	500	600	20,900	18,200
Sept. 13-14	72	60	50	356	....	....	49	1.0	....	....	140	....	....	281	487	1,000	1,291	42,000	....
Sept. 18-19	73	61	55	272	....	....	56	4.0	....	....	100	....	....	363	40	1,008	1,140	14,000	1,170
Sept. 21-22	73	62	56	148	....	....	42	2.0	....	....	72	....	....	159	30	775	1,266	9,300	8,100
Sept. 23-24	72	61	50	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Sept. 26-27	72	59	43	56	....	....	44	4.4	....	....	160	....	....	187	335	350	891	18,000	17,300
Oct. 1- 2	70	57	48	240	....	....	36	8.0	....	....	228	....	....	177	45	750	1,283	34,000	24,000
Oct. 4- 5	73	57	52	120	....	....	57	2.8	....	....	496	....	....	282	....	....	....	....	....
Oct. 6	70	54	44	....	....	....	....	....	....	....	....	....	....	....	10	1,667	2,350	6,200	....
Oct. 9-10	70	50	37	....	....	....	63	5.0	....	....	324	....	....	256	140	991	1,666	1,520	390
Oct. 14-15	64	50	50	140	....	....	61	11.0	....	....	428	....	....	214	312	1,950	2,075	....	....
Oct. 17-18	69	52	54	236	....	....	48	8.0	....	....	348	....	....	178	405	733	1,525	....	....
Oct. 22-23	59	47	36	176	....	....	68	12.0	....	....	112	....	....	223	220	650	700	1,500	80

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[1] Effluent from septic tank.

DETAILED CHEMICAL AND BACTERIOLOGICAL ANALYSES OF EFFLUENT OF SAND FILTER NO. 2.

	Net rate on filter G. A. O.	Chemical analyses (p. p. m.).																Bacteria (1,000 per c. c.).	
		Suspended solids.	Residue on evaporation.	Turbidity.	Nitrogen as—				Alkalinity.	Acidity.	Putrescibility hours to reduce M. B. at room temperature.	Diss. oxygen.		Oxygen consumed: 30 min. 96° C.	Oxygen demand at 20° C.			Agar 30° C., 48 hours.	Endo plates, red colonies.
					Total organic.	Ammoniacal.	Nitrites.	Nitrates.				P. P. M.	Per cent sat.		24 hours.	5 days.	10 days.		
1917.																			
July 11-12	......	42	......	......	1.10	2.5	0.200	8.0	408	......	144+	1.5	16	18.0	5.0	......	49	......	......
July 22-23	55,000	41	......	......	4.00	1.8	.070	3.0	230	......	144+	1.0	12	12.0	6.0	24	70	......	......
July 25-26	[illegible], 200	6	......	......	2.00	1.0	.400	10.0	220	......	144+	2.9	35	10.0	3.0	28	......	......	......
July 30-31	69,700	39	......	......	2.40	.8	1.600	9.0	500	......	144+	1.9	23	14.0	44.0	108	......	......	......
Aug. 2-3	90,500	22	......	......	3.60	1.1	1.200	10.0	348	......	144+	2.2	25	9.6	2.3	24	47	......	......
Aug. 7-8	80,200	......	......	......	.60	1.4	.800	20.0	400	......	144+	......	......	6.7	2.2	18	43	17	......
Aug. 10-11	67,000	......	......	......	......	1.4	.500	18.0	420	......	144+	......	......	5.8	1.5	14	22	1	......
Aug. 12-13	75,000	......	......	......	2.00	.9	.700	15.0	400	......	144+	5.1	58	7.3	7.6	37	56	7	......
Aug. 15-16	79,800	......	......	......	1.40	.5	.300	15.0	388	......	144+	5.3	60	4.6	.6	10	26	21	1
Aug. 20-21	81,400	......	......	......	.40	.4	.500	12.0	384	......	144+	3.9	44	6.2	10.0	31	......	58	70
Aug. 23-24	77,500	......	......	......	......	.3	.200	30.0	376	......	144+	4.1	46	4.8	1.9	10	36	......	......
Aug. 26-27	80,700	......	......	......	......	......	......	......	......	......	......	......	......	......	3.3	12	24	282	......
Aug. 28-29	84,000	......	......	......	.40	.1	.200	4.0	420	......	96	3.8	41	6.6	......	......	......	248	137
Aug. 31 Sept. 1	72,200	......	......	......	.60	.2	.200	4.0	384	......	144+	4.5	49	4.6	2.7	8	24	42	3
Sept. 2-3	76,000	......	......	......	1.00	......	.600	7.0	380	......	144+	3.6	38	8.0	15.0	42	46	......	......
Sept. 6-7	69,400	......	......	......	......	.3	.500	15.0	340	......	144+	4.4	46	5.5	11.0	24	41	......	......
Sept. 10-11	67,500	......	......	......	.70	.1	.100	8.0	348	......	144+	6.2	62	6.0	2.2	10	21	1,500	1,380
Sept. 13-14	60,700	......	......	......	.60	......	.100	5.0	392	......	144+	6.0	59	8.4	7.8	10	20	1,700	......
Sept. 18-19	75,700	38	......	......	2.10	.3	.200	8.0	360	......	42	4.7	47	17.0	13.0	32	37	670	630
Sept. 21-22	80,800	......	......	......	2.40	......	.100	2.5	376	......	144+	4.6	46	10.0	14.0	26	42	......	......
Sept. 23-24	70,400	......	......	......	2.80	......	.100	5.0	372	......	144+	6.3	63	6.2	.5	8	11	......	......
Sept. 26-27	77,100	......	......	......	1.40	......	......	7.5	360	......	144+	6.5	64	5.2	1.5	12	18	......	90
Oct. 1-2	80,200	68	......	......	2.20	......	.100	2.4	296	......	40	5.1	50	9.4	10.0	23	39	1,000	3,600
Oct. 4-5	82,200	34	......	......	3.10	.3	......	4.0	436	......	34	......	......	11.0	......	......	......	......	......
Oct. 6	74,000	......	......	......	......	......	......	......	......	......	64	2.1	19	......	13.0	......	......	640	......
Oct. 9-10	50,300	......	......	......	1.80	.2	......	4.0	392	......	32	3.5	31	8.4	12.0	24	60	85	22
Oct. 14-15	58,100	106	......	......	1.80	.2	.400	2.0	584	......	16	7.5	63	9.0	9.0	65	70	......	......
Oct. 17-18	37,600	......	......	......	1.20	.3	......	.6	360	......	16	5.2	47	5.8	9.7	21	60	......	......
Oct. 22-23	30,100	......	......	......	1.80	.2	......	3.0	304	......	144+	7.2	60	6.5	4.2	44	62	118	52